Appendix C

Risk Assessment Review for COU, POU, and OU3

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C1.0 Introduction

This appendix presents the methodology for reviewing and evaluating changes to chemical and radiological risk assessment parameters that took effect during this five-year review (FYR) period and details the results of the risk evaluation. The methodology used for this evaluation is based on the methodology used for the comprehensive risk assessment (CRA) completed in 2006. The CRA included a human health and ecological risk assessments for the Central Operable Unit (COU) and the Peripheral Operable Unit (POU); a separate risk assessment was completed for Operable Unit 3 (OU3) (DOE 1996). A summary of the CRA may be found in the Third FYR report (DOE 2012), and the complete CRA is found as an appendix to the Remedial Investigation/Feasibility Study (RI/FS) Report (DOE 2006).

In accordance with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) guidance, this FYR must provide an evaluation of changes to risk assessment factors to determine if these changes impact the risks presented by residual contamination left within the COU. The conclusions of this evaluation are then used to determine if the remedy remains protective.

Although this FYR risk evaluation is limited to risks posed by residual contamination within the COU, a separate review of the impacts of changes to risk assessment factors was conducted for the POU and OU3. The purpose of this separate review was to determine if the unlimited use/unrestricted exposure (UU/UE) designation is still valid at both OUs. The POU and OU3 were both deleted from the National Priorities List (NPL) in 2007 because they posed no significant threat to public health or the environment (Volume 72 *Federal Register* p. 29276 [72 FR 29276]).

C2.0 Central Operable Unit

In the RI/FS Report (DOE 2006), the nature and extent of residual contamination in soil and sediment were evaluated after completion of the Rocky Flats Cleanup Agreement accelerated actions. Each nature and extent of contamination evaluation identified analytes of interest (AOIs). AOIs are chemicals that have been detected at concentrations that may contribute to the risk to future receptors. The evaluation studied the extent of contaminants within the COU and POU and evaluated which chemicals remained after the completed accelerated actions. The soil AOIs identified in the RI/FS Report are presented in Table C-1.

In 2006, a comprehensive risk assessment was completed for the COU and POU to quantify the risk of residual contamination remaining after accelerated cleanup actions (DOE 2006). The CRA was conducted in accordance with the *Comprehensive Risk Assessment Work Plan and Methodology* (DOE 2004), approved by the U.S. Environmental Protection Agency (EPA) and the Colorado Department of Public Health and Environment (CDPHE). Calculations and conclusions in the CRA were based on post-remediation data; that is, data collected after the completion of all Rocky Flats Cleanup Agreement accelerated actions. To facilitate the CRA, the lands comprising the COU and POU were divided into the 12 exposure units (EUs) shown in Figure C-1. The basic methodology for conducting human health risk assessments, as described in the *Risk Assessment Guidance for Superfund* (EPA 1989), has not changed since the CRA was completed.

Table C-1. Soil Analytes of Interest Identified in the Remedial Investigation/Feasibility Study Report

Surface Soil (0–0.5 feet)	Subsurface Soil (0.5–8 feet)	Subsurface Soil (>8 feet)
Radionuclides		
Americium-241 Plutonium-239/240 Uranium-233/234 Uranium-235 Uranium-238	Americium-241 Plutonium-239/240 Uranium-235 Uranium-238	Plutonium-239/240
Metals		
Aluminum Arsenic Chromium (total) Vanadium	Chromium (total) Lead	
Volatile Organic Compounds (VOCs)		
	Tetrachloroethene	1,1,2,2-Tetrachloroethane Carbon tetrachloride Chloroform Methylene chloride Tetrachloroethene Trichloroethene
Semivolatile Organic Compounds (SVOCs)		
Benzo[*a*]pyrene Dibenz[*a,h*]anthracene	Benzo[*a*]pyrene	Benzo[*a*]pyrene
Polychlorinated Biphenyls (PCBs)		
Aroclor-1254 Aroclor-1260 2,3,7,8-TCDD		Aroclor-1260

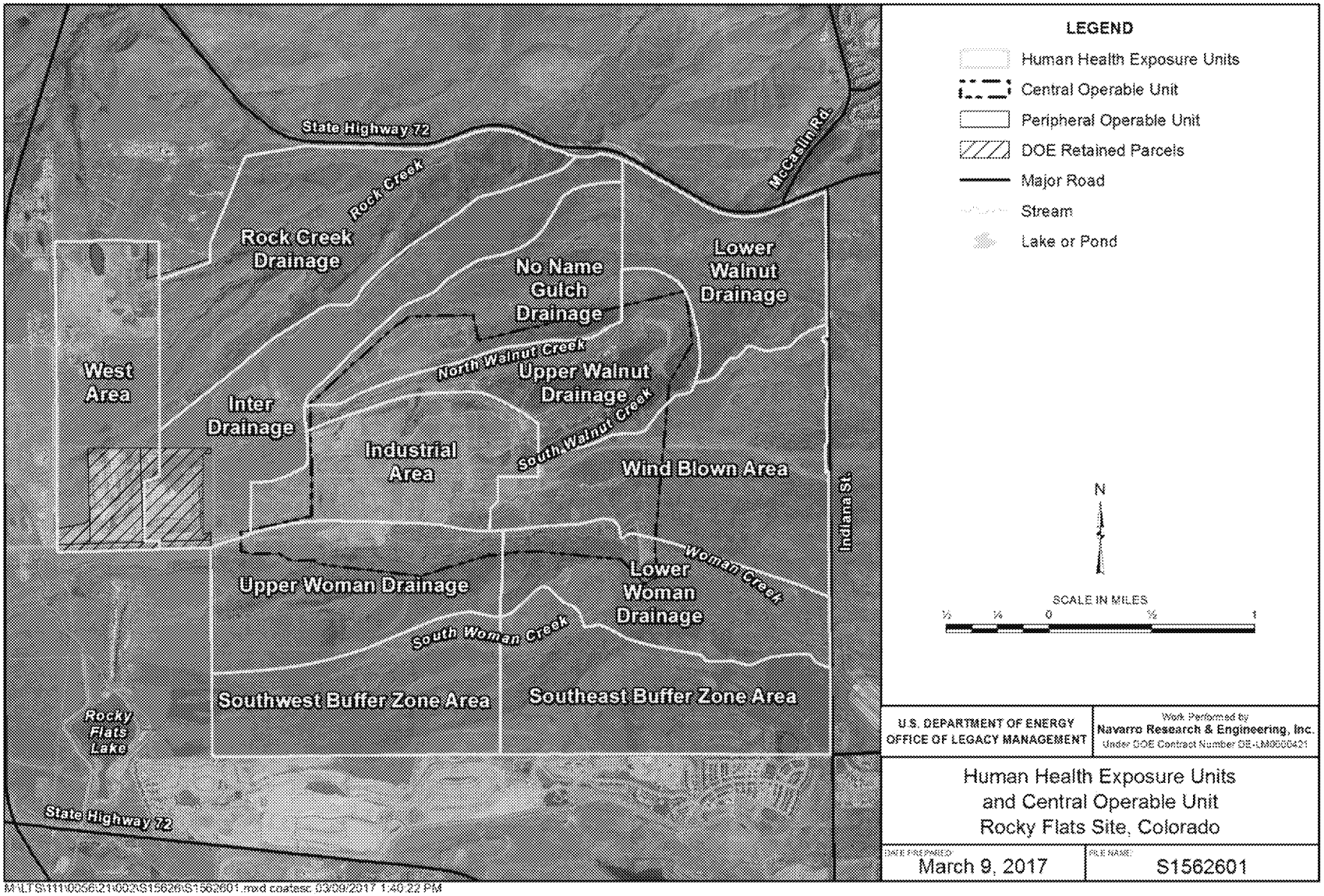

Figure C-1. Human Health EUs and COU Boundary

C2.1 Risk Definitions

This section presents the definitions of key risk terms used throughout this appendix.

95 percent upper confidence limit (95UCL): The statistical upper bound estimate of the mean for a set of samples and a conservative measure of the average concentration. As a general rule, EPA recommends use of the 95UCL as the exposure point concentration for soils at a site (EPA 2002).

Cancer risk: The added probability of an individual or population of developing cancer during a lifetime as a result of exposure to site contaminants. The acceptable risk range for CERCLA sites is an added risk of less than 1 in 1,000,000 (1×10^{-6}) to a maximum of 1 in 10,000 (1×10^{-4}).

Dose conversion factor (DCF): The dose to the human body associated with an exposure to a radionuclide (usually presented in millirem per picocurie [mrem/pCi] or millirem per year [mrem/year]/picocurie per gram [pCi/g]).

Hazard quotient (HQ): The ratio of the exposure level of a single substance to an acceptable noncarcinogenic toxicity value. If multiple substances are present, hazard quotients are summed in a hazard index. For CERCLA sites, the maximum acceptable hazard index is 1.0.

Maximum detected concentration (MDC): Maximum concentration detected in any soil sample for a given constituent and exposure unit.

Slope factor: An estimate of the risk of developing cancer associated with exposure to a carcinogenic or potentially carcinogenic substance.

C2.2 CRA Review Methodology

As one of thean initial steps in the comprehensive risk assessment process (Figure x-x), residual concentrations of constituents in soil for each EU were compared to preliminary remediation goals (PRGs) developed for a wildlife refuge worker (WRW). The PRGs represent concentrations for individual chemicals that would equate to a carcinogenic risk of 1×10^{-6} or a noncarcinogenic HQ of 0.1 based on the exposure assumptions for the WRW. The 2006 CRA used a HQ of 0.1 as an initial, conservative screening level; a HQ greater thanof 1.0 ~~is the maximum permissible limit~~indicates an exposure that exceeds a reference dose. The PRGs were developed using toxicity data that were current at the time of the CRA and were developed for exposures to both surface and subsurface soils. PRGs for subsurface soils are higher than those for surface soils, as it was assumed that the exposure frequency would be much lower (20 days per year compared to 230 days per year). The MDC for each detected constituent at each EU was compared to its respective PRG. If the MDC was less than the PRG, the constituent was eliminated from further consideration. If the MDC exceeded the PRG, the 95UCL of the mean for that constituent was compared to the PRG. If the 95UCL was less than the PRG, the constituent was eliminated from further consideration. If the 95UCL exceeded the PRG, the constituent was further evaluated based on frequency of detection, comparison to background concentrations, and professional judgement. Constituents passing through these remaining screening criteria were identified as contaminants of concern (COCs) for each EU (Table C-2)

and were further evaluated in the CRA. (Note that the analytes of interest screening process and CRA EU-specific COC screening process were somewhat different and produced different results.) In the 2006 CRA, COCs were only identified for surface soils. All constituents in subsurface soils were eliminated by the 95UCL screen and no quantitative risks were calculated.

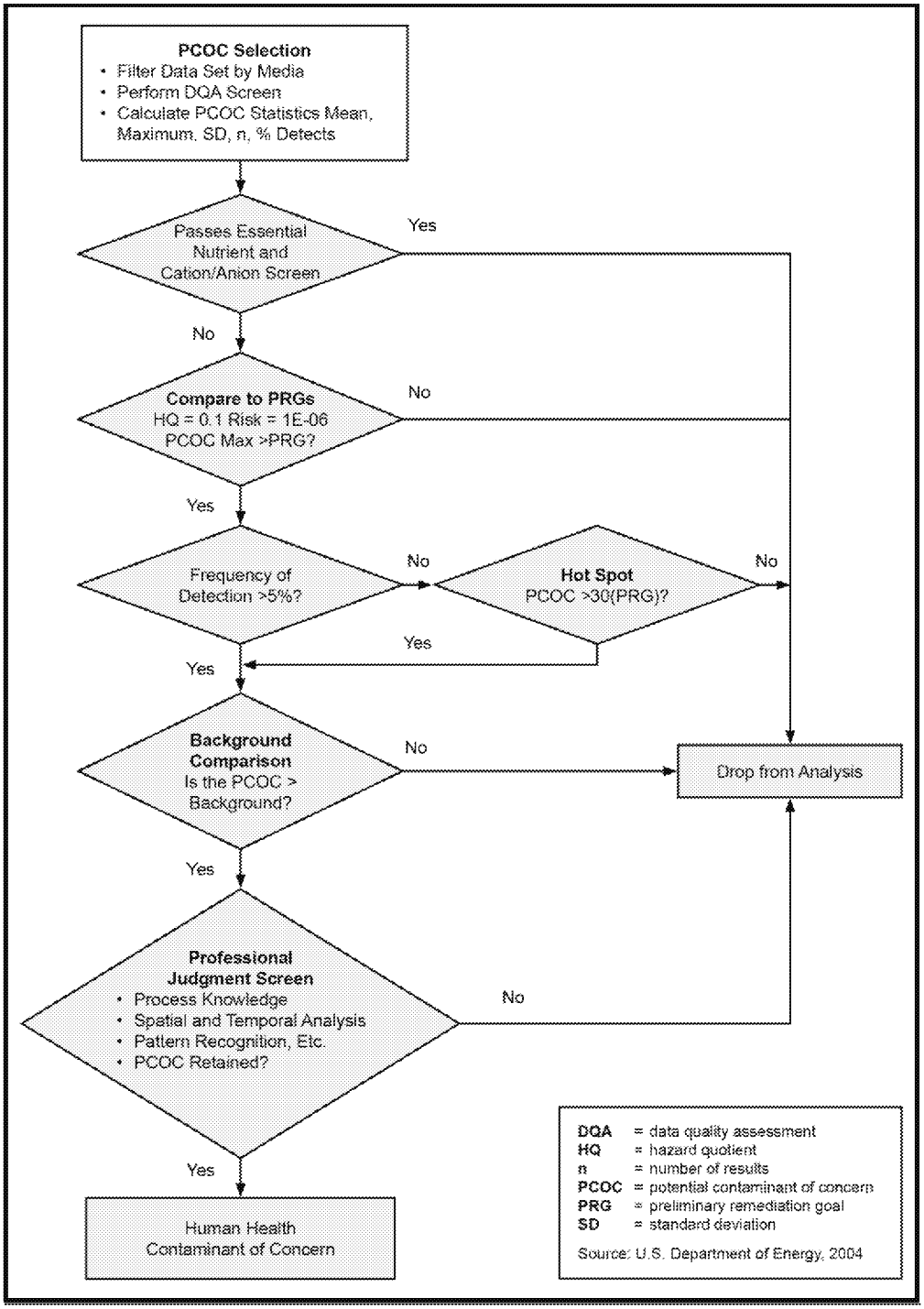

Figure x-x. CRA Constituent Review Process

Table C-2. Surface Soil COCs Identified for Each EU in the CRA

Constituent	Exposure Unit											
	Industrial Area EU	Upper Woman Drainage EU	Wind Blown EU	No Name Gulch EU	Upper Walnut Drainage EU	Lower Woman Drainage EU	Rock Creek EU	Lower Walnut Drainage EU	Inter Drainage EU	West Area EU	Southwest Buffer Zone Area EU	Southeast Buffer Zone Area EU
Part of COU	•	•	•	•	•	•						
Part of POU	•	•	•	•	•	•	•	•	•	•	•	•
Arsenic	X	-	X	-	-	-	-	-	-	-	-	-
Vanadium	-	-	-	X	-	-	-	-	-	-	-	-
2,3,7,8-TCDD	-	X	-	-	-	-	-	-	-	-	-	-
Benzo[*a*]pyrene	X	X	-	-	X	-	-	-	-	-	-	-
Plutonium-239/240	-	-	X	-	-	-	-	-	-	-	-	-

Abbreviations:
2,3,7,8-TCDD = 2,3,7,8-tetrachlorodibenzo-*p*-dioxin
X = constituent was designated a COC in the 2006 CRA
- = constituent was not designated a COC in the 2006 CRA

C2.3 FYR Risk Evaluation

The following sections discuss the review methodology and results from this FYR risk evaluation for the COU. The sections have been separated into chemical and radionuclide constituents because the methodologies for these evaluations were slightly different.

C2.3.1 Chemical Constituent Review Methodology

Because the first two steps of the COC screening process in the CRA relied on a comparison of residual soil concentrations with the WRW PRGs, any subsequent changes to exposure assumptions or toxicity values used to calculate the PRGs could change the outcome of the screening process. For this FYR risk evaluation, a methodology similar to that described above for the CRA was applied to determine the impact of changes to risk assessment parameters for surface soils. Figure C-2 presents the screening methodology. In lieu of recalculating over 200 site-specific PRGs for a WRW, this FYR risk evaluation utilized the EPA regional screening levels (RSLs) for industrial soil as a proxy for revised WRW PRGs (EPA 2016a). The RSLs incorporate current toxicity data and methodologies for the same exposure pathways of concern for the WRW. The default exposure assumptions for the industrial soil scenario are very similar to those used for the WRW for surface soils. Table C-3 compares the key assumptions used in RSL and site-specific PRG calculations. Where exposure factors are not the same, those used by EPA tend to be more conservative (i.e., assume a greater degree of exposure). Therefore, it was determined that the EPA industrial soil RSLs were an acceptable screening tool to represent

updated surface soil WRW PRGs (referred to as "updated WRW RSLs" for the remainder of this appendix).

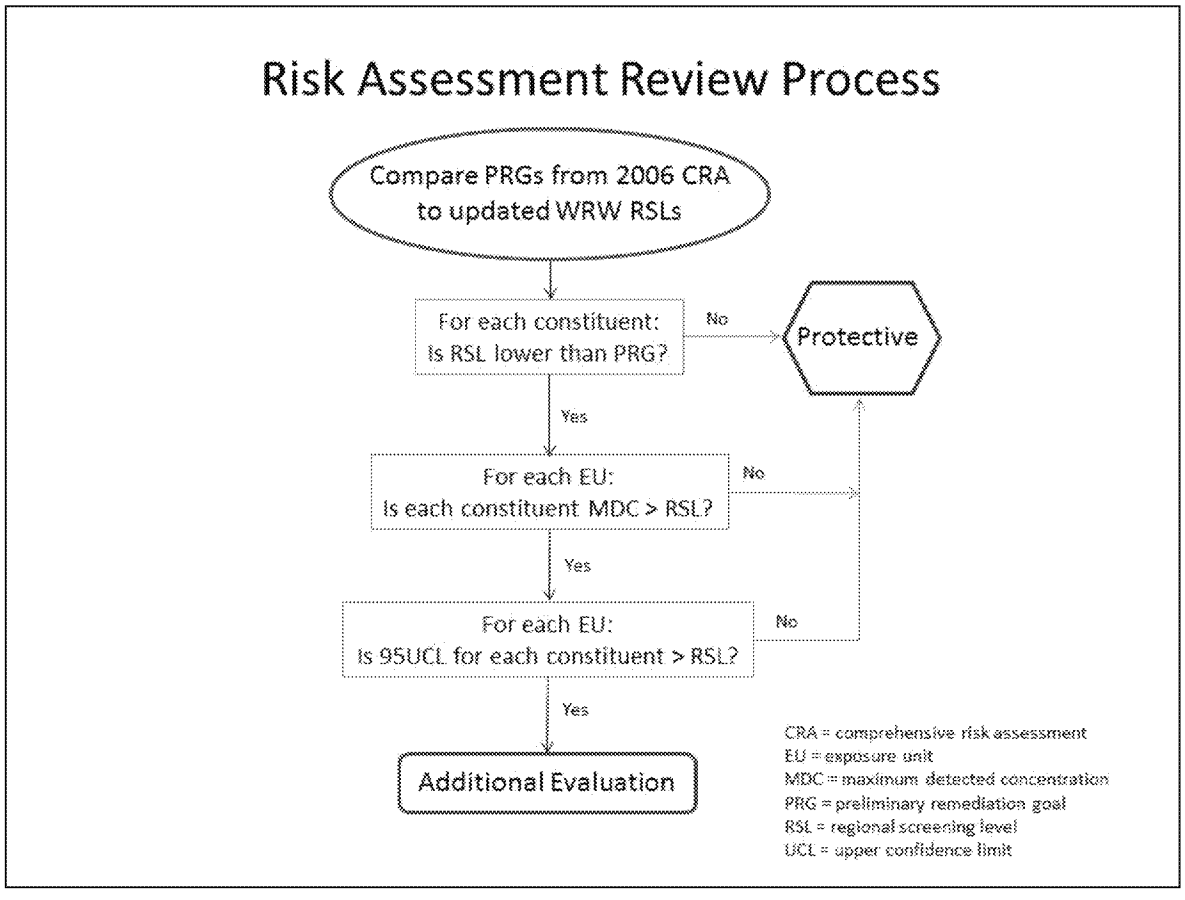

Figure C-2. FYR Risk Assessment Review Process

Table C-3. Comparison of Key Exposure Assumptions for RSLs and PRGs

Exposure Factor (units)	EPA RSL Default Value	WRW PRG Assumption
Frequency of exposure (days/year)	250	Surface soils, 230 Subsurface soils, 20
Exposure duration (years)	25	18.7
Exposure time (hours/day)	8	8
Soil ingestion rate (milligrams/day)	100	100
Adult body weight (kilograms)	80	70
Skin surface area (square centimeters)	3527	3300

The complete list of surface soil PRGs developed for the comprehensive risk assessment was compared to the updated WRW RSLs list (EPA 2016). Of the more than 200 original PRGs that were evaluated, slightly more than half of the PRGs were higher than (i.e., greater than) the updated RSLs. This means that some COCs could have been eliminated during the original CRA

screening process that would have been retained based on more current data. The vast majority of the lower RSL values were for organic chemicals of which many are volatile organic compounds (VOCs). EPA has recently finalized guidance on vapor intrusion (EPA 2015) and as a result has updated information on many VOCs included in the RSL tables. Additionally, the EPA approach to evaluating risks for the inhalation pathway was finalized in 2009. The methodology used in the CRA reflects older guidance for estimating exposures for this pathway. It is likely that a combination of these factors explain why such a large number of the PRGs are higher than current RSLs. Decreases for most constituents were within an order of magnitude, but RSLs for a few constituents are several orders of magnitude lower than PRGs (e.g., cyclohexane).

Where PRGs were lower than current RSLs, it was assumed that results of the original screening process are still valid. Where RSLs were lower than PRGs, a rescreening of the EU statistical data was performed. EPA RSLs that were lower than PRGs were compared to data presented in the CRA for each EU. The analytical data (MDCs and 95UCL values) used in this FYR are the same data used in the 2006 comprehensive risk assessment; no new data were collected to support this FYR. The MDCs and 95UCLs used in the surface soil screening were compared to the RSLs. If 95UCL data were not already tabulated, a 95UCL was calculated from statistical data provided in the CRA. If MDCs or 95UCLs were lower than the current RSLs, constituents were eliminated from further consideration. All other constituents were retained for further evaluation. Table C-4 presents the results of the chemical screening process by EU; Table C-5 summarizes the screening process by constituent.

Table C-4. Surface Soil Chemical Constituent Screening Results by EU

Constituent	Industrial Area EU	Upper Woman Drainage EU	Wind Blown EU	No Name Gulch EU	Upper Walnut Drainage EU	Lower Woman Drainage EU	Rock Creek EU	Lower Walnut Drainage EU	Inter Drainage EU	West Area EU	Southwest Buffer Zone Area EU	Southeast Buffer Zone Area EU
Arsenic	X	-	X	-	-	-	-	-	-	-	-	-
Vanadium	-	-	-	X	-	-	-	-	-	-	-	-
2,3,7,8-TCDD	-	X	-	-	-	-	-	-	-	-	-	-
Aroclor-1254	X	-	X	X	-	-	-	-	-	-	-	-
Aroclor-1260	X	-	-	-	-	-	-	-	-	-	-	-
Benzo[*a*]anthracene	X	X	-	-	-	-	-	-	-	-	-	-
Benzo[*a*]pyrene	X	X	X	X	X	-	-	-	-	-	-	-
Benzo[*b*]fluoranthene	X	X	-	-	-	-	-	-	-	-	-	-
Cobalt	X	-	-	-	-	-	-	-	-	-	-	-
Dibenz[*a,h*]anthracene	X	X	-	-	-	-	-	-	-	-	-	-
Indeno[1,2,3-*cd*]pyrene	-	X	-	-	-	-	-	-	-	-	-	-
Lead and compounds	-	-	-	X	-	-	-	-	-	-	-	-
Mercury (elemental)	X	-	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	X		-	-	-	-	-	-	-	-	-
N-Nitroso-di-*n*-propylamine	-	-	X	-	-	-	-	-	-	-	-	-
Uranium (soluble salts)[a]	X	X	-	-		-	-	-	-	-	-	-

Notes:

[a] The revised risk-based screening level for uranium was calculated using the oral reference dose recommended in EPA's December 2016 memorandum (EPA 2016b). This screening level is lower than that contained in EPA's current RSLs.

X = constituent MDC > WRW RSL

- = constituent MDC or 95UCL < WRW RSL

Shaded boxes indicate 95UCL > WRW RSL.

Arsenic and vanadium were included in this table because these constituents were identified as COCs in the CRA and their 95UCL exceeds their PRG.

Abbreviations:

2,3,7,8-TCDD = 2,3,7,8-tetrachlorodibenzo-*p*-dioxin

Table C-5. Surface Soil Chemical Constituent FYR Screening Results by Constituent

All Constituents with PRGs[a]	Constituents Where EPA RSL < PRG[b]	Constituents Where EPA RSL < PRG (any EU)[c]	Constituents Where MDC > EPA RSL (any EU)[d]
Acenaphthene	-		
Acenapthylene	-		
Acetone	x	x	
Acrolein	x		
Acrylonitrile	x		
Alachlor	-		
Aldicarb	-		
Aldicarb Sulfone	-		
Aldicarb sulfoxide	-		
Aldrin	-		
Aluminum	-		
Ammonia	-		
Anthracene	-		
Antimony (metallic)	-		
Aroclor 1016	-		
Aroclor 1221	x		
Aroclor 1232	x		
Aroclor 1242	x	x	
Aroclor 1248	x	x	
Aroclor 1254	x	x	x
Aroclor 1260	x	x	x
Arsenic, Inorganic	x		
Atrazine	x		
Barium	x		
Benzene	x	x	
Benzidine	x		
Benz[a]anthracene	x	x	x
Benzo[a]pyrene	x	x	x
Benzo[b]fluoranthene	x	x	x
Benzo[g,h,i]perylene	-		
Benzo[k]fluoranthene	x	x	
Benzoic Acid	-		
Benzyl Alcohol	x	x	
Beryllium and compounds	-		
Bis(2-chloroethyl)ether	x		
Bis(2-chloro-1-methylethyl) ether	-		

All Constituents with PRGs[a]	Constituents Where EPA RSL < PRG[b]	Constituents Where EPA RSL < PRG (any EU)[c]	Constituents Where MDC > EPA RSL (any EU)[d]
Bis(2-ethylhexyl)phthalate	x	x	
Boron And Borates Only	-		
Bromodichloromethane	x	x	
Bromoform	x		
Bromomethane	x	x	
2-Butanone (Methyl Ethyl Ketone)	x	x	
Butyl Benzyl Phthalate	x	x	
Cadmium (Diet)	-		
Carbazole	-		
Carbofuran	-		
Carbon Disulfide	x	x	
Carbon Tetrachloride	x	x	
Chlordane-alpha	-		
Chlordane-beta	-		
Chlordane-gamma	x		
4-Chloroaniline	x		
Chlorobenzene	x	x	
Ethyl Chloride (Chloroethane)	-		
Chloroform	x	x	
Chloromethane (methyl chloride)	x	x	
4-Chloro-3-methylphenol (Cresol, p-chloro-m-)	-		
2-Chloronaphthalene (Beta-)	x		
Chlorophenol, 2-	-		
Chlorpyrifos	x		
Chromium(III), Insoluble Salts	-		
Chromium(VI)	x	x	x
Chrysene	x	x	
Cobalt	x	x	x
Copper	-		
Cyanide (CN-)	x		
Cyclohexane	x		
DDD	x	x	
DDE, p,p'-	x	x	
DDT	x	x	
Dalapon	-		
Demeton	-		
Dibenz[a,h]anthracene	x	x	x
Dibenzofuran	-	x	

All Constituents with PRGs[a]	Constituents Where EPA RSL < PRG[b]	Constituents Where EPA RSL < PRG (any EU)[c]	Constituents Where MDC > EPA RSL (any EU)[d]
Dibromochloromethane	x		
1,2-Dibromo-3-chloropropane	x		
Dibutyl Phthalate	-		
Dicamba	-		
Dichlorobenzene, 1,2-	x		
Dichlorobenzene, 1,3-	-		
Dichlorobenzene, 1,4-	-	-	
Dichlorobenzidine, 3,3'-	x		
Dichlorodifluoromethane	x		
Dichloroethane, 1,1-	x		
Dichloroethane, 1,2-	x		
Dichloroethylene, 1,1-	-		
Dichloroethene, 1,2- (total)	-		
Dichlorophenol, 2,4-	-		
Dichlorophenoxy Acetic Acid, 2,4-	-		
Dichlorophenoxy)butyric Acid, 4-(2,4-	-		
Dichloropropane, 1,2-	x	x	
Dichloropropane, 1,3-	-		
Dichloropropene, cis-1,3-	-		
Dichloropropene, trans-1,3-	-		
Dieldrin	x	x	
Diethyl Ether (Ethyl Ether)	-		
Di(2-ethylhexyl)adipate	x		
Diethyl Phthalate	-		
Dimethoate	x		
Dimethylphenol, 2,4-	x	x	
Dimethylphthalate	x	x	
Dinitro-o-cresol, 4,6-	x		
Dinitrophenol, 2,4-	x	x	
Dinitrotoluene, 2,4-	x		
Dinitrotoluene, 2,6-	x		
di-N-Octyl Phthalate	x	x	
Dinoseb	-		
Dioxane, 1,4-	x		
TCDD, 2,3,7,8-	x	x	x
Diphenylhydrazine, 1,2-	x		
Diquat	-		
Endosulfan I	-		

All Constituents with PRGs[a]	Constituents Where EPA RSL < PRG[b]	Constituents Where EPA RSL < PRG (any EU)[c]	Constituents Where MDC > EPA RSL (any EU)[d]
Endosulfan II	-		
Endosulfan Sulfate	-		
Endosulfan (technical)	-		
Endrin	-		
Endrin aldehyde	-		
Endrin ketone	-		
Ethyl Acetate	x		
Ethylbenzene	x	x	
Ethylene dibromide (Dibromoethane, 1,2-)	-		
Fluoranthene	-		
Fluorene	x	x	
Fluorine (Soluble Fluoride)	-		
Glyphosate	-		
Guthion (Azinphos-methyl)	-		
Heptachlor	x		
Heptachlor Epoxide	-		
Hexachlorobenzene	x	x	
Hexachlorobutadiene	x	x	
Hexachlorocyclohexane, Alpha-	x		
Hexachlorocyclohexane, Beta-	x		
Hexachlorocyclohexane, Gamma- (Lindane)	x		
Hexachlorocyclohexane, Delta-	-		
Hexachlorocyclohexane, Technical	x		
Hexachlorocyclopentadiene	x		
Hexachlorodibenzo-p-dioxin	x		
HxCDD, 1,2,3,6,7,8-	x		
HxCDD, 1,2,3,7,8,9-	x		
Hexachloroethane	x		
Indeno[1,2,3-cd]pyrene	x	x	x
Iron	-		
Isobutyl Alcohol	-		
Isophorone	x	x	
Isopropylbenzene (Cumene)	-		
Lead and Compounds	x	x	x
Lithium	x	x	
Manganese (Diet)	-		
Mercury (elemental)	x	x	x
Methoxychlor	-		

All Constituents with PRGs[a]	Constituents Where EPA RSL < PRG[b]	Constituents Where EPA RSL < PRG (any EU)[c]	Constituents Where MDC > EPA RSL (any EU)[d]
MCPA	-		
MCPP	-		
Methylene Chloride	-		
Methyl Methacrylate	x		
Methylnaphthalene, 2-	x	x	
Methyl Isobutyl Ketone (4-methyl-2-pentanone)	x	x	
2-Methylphenol (Cresol, o-)	-		
4-Methylphenol (Cresol, p-)	-		
Methyl tert-Butyl Ether (MTBE)	x		
Mirex	x		
Molybdenum	-		
Naphthalene	x	x	x
Nickel Soluble Salts	-		
Nitrate	-		
Nitrite	-		
Nitroaniline, 2-	-		
Nitroaniline, 4-	x		
Nitrobenzene	x		
Nitrophenol, 4-	-		
Nitroso-di-N-butylamine, N-	x		
Nitrosodiethylamine, N-	x		
Nitrosodimethylamine, N-	x		
Nitrosodiphenylamine, N-	x		
Nitroso-di-N-propylamine, N-	x	x	x
Nitrosopyrrolidine, N-	x		
Nitrotoluene, p-	x		
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	-		
Oxamyl	-		
Parathion	-		
Pentachlorobenzene	-		
Pentachlorophenol	x	x	
Phenanthrene	-		
Phenol	-		
Picloram	-		
Pyrene	-		
Selenium	-		
Silver	-		

All Constituents with PRGs[a]	Constituents Where EPA RSL < PRG[b]	Constituents Where EPA RSL < PRG (any EU)[c]	Constituents Where MDC > EPA RSL (any EU)[d]
Simazine	x		
Strontium, Stable	-		
Styrene	x	x	
Sulfide	-		
Tetrachlorobenzene, 1,2,4,5-	-		
Tetrachloroethane, 1,1,1,2-	x		
Tetrachloroethane, 1,1,2,2-	x	x	
Tetrachloroethylene	-		
Tetrachlorophenol, 2,3,4,6-	-		
Thallium (Soluble Salts)	x	x	
Tin	-		
Titanium	-		
Toluene	-		
Toxaphene	x		
Trichlorobenzene, 1,2,4-	x	x	
Trichloroethane, 1,1,1-	x	x	
Trichloroethane, 1,1,2-	x		
Trichloroethylene	-		
Trichlorofluoromethane	-		
Trichlorophenol, 2,4,5-	-		
Trichlorophenol, 2,4,6-	x	x	
Trichlorophenoxypropionic acid, -2,4,5	-		
Trichloropropane, 1,2,3-	x	x	
Trichloro-1,2,2-trifluoroethane, 1,1,2-	x	x	
Trinitrotoluene, 2,4,6-	-		
Uranium (Soluble Salts)	x	x	x
Vanadium and Compounds	-		
Vinyl Acetate	x		
Vinyl Chloride	x		
Xylene, P-	x		
Xylene, m-	x		
Xylene, o-	x		
Xylenes	x	x	
Zinc and Compounds	-		

[a] This column lists all constituents for which WRW PRGs were developed. The constituents are arranged in the same order as they were in the CRA methodology document where the PRGs were developed (DOE 2004).
[b] This column lists all constituents where the May 2016 EPA RSLs were lower than the WRW PRGs.
[c] This column includes all constituents that were detected and carried through the original CRA screening process for any EU.

[d] This column contains all constituents with an MDC that exceeded an EPA RSL. Note that arsenic and vanadium are not carried past the first column in this table because the EPA RSLs are greater than the WRW PRGs and rescreening isn't required.

[e] The revised risk-based screening level for uranium was calculated using the oral reference dose recommended in EPA's December 2016 memorandum (EPA 2016). This screening level is lower than that contained in EPA's current RSLs.

Table C-5. Surface Soil Chemical Constituent Screening Results by Constituent

All Constituents with PRGs[a]	Constituents Where EPA RSL < PRG[a]	Constituents Where EPA RSL < PRG (any EU)[a]	Constituents Where MDC > EPA RSL (any EU)[a]
Acenaphthene	1,1,1-Trichloroethane	1,1,1-Trichloroethane	2,3,7,8-TCDD,
Acenapthylene	1,1,2,2-Tetrachloroethane	1,1,2,2-Tetrachloroethane	Aroclor 1254
Acetone	1,1,2-Trichloro-1,2,2-trifluoroethane	1,1,2-Trichloro-1,2,2-trifluoroethane	Aroclor 1260
Acrolein	1,1,2-Trichloroethane	1,2,3-Trichloropropane	Benz[*a*]anthracene
Acrylonitrile	1,1-Dichloroethane,	1,2,4-Trichlorobenzene	Benzo[*a*]pyrene
Alachlor	1,2,3-Trichloropropane	1,2-Dichloropropane	Benzo[*b*]fluoranthene
Aldicarb	1,2,4-Trichlorobenzene	2,4,6-Trichlorophenol	Cobalt
Aldicarb sulfone	1,2-Dibromo-3-chloropropane	2,4-Dimethylphenol	Dibenz[*a,h*]anthracene
Aldicarb sulfoxide	1,2-Dichlorobenzene	2,4-Dinitrophenol	Indeno[1,2,3-*cd*]pyrene
Aldrin	1,2-Dichloroethane	2,3,7,8-TCDD,	Lead and compounds
Aluminum	1,2-Dichloropropane	2-Butanone (methyl ethyl ketone)	Mercury (elemental)
Ammonia	1,2-Diphenylhydrazine	2-Methylnaphthalene,	Naphthalene
Anthracene	1,4-Dioxane	4-methyl-2-pentanone (methyl isobutyl ketone)	Nitroso-di-*n*-propylamine, N-
Antimony (metallic)	2,4,6-Trichlorophenol	Acetone	Uranium (soluble salts)[b]
Aroclor 1016	2,4-Dimethylphenol	Aroclor 1242	
Aroclor 1221	2,4-Dinitrophenol	Aroclor 1248	
Aroclor 1232	2,4-Dinitrotoluene	Aroclor 1254	
Aroclor 1242	2,6-Dinitrotoluene	Aroclor 1260	
Aroclor 1248	2,3,7,8-TCDD,	Benzene	
Aroclor 1254	2-Butanone (methyl ethyl ketone)	Benz[*a*]anthracene	
Aroclor 1260	2-Chloronaphthalene (beta-)	Benzo[*a*]pyrene	
Arsenic, Inorganic	2-Methylnaphthalene	Benzo[*b*]fluoranthene	
Atrazine	3,3'-Dichlorobenzidine	Benzo[*k*]fluoranthene	
Barium	4,6-Dinitro-o-cresol	Benzyl alcohol	
Benzene	4-Chloroaniline	Bis(2-ethylhexyl)phthalate	
Benzidine	4-methyl-2-pentanone (methyl isobutyl ketone)	Bromodichloromethane	
Benz[*a*]anthracene	4-Nitroaniline,	Bromomethane	
Benzo[*a*]pyrene	Acetone	Butyl benzyl phthalate	
Benzo[*b*]fluoranthene	Acrolein	Carbon disulfide	
Benzo[*g,h,i*]perylene	Acrylonitrile	Carbon tetrachloride	
Benzo[*k*]fluoranthene	Aroclor 1221	Chlorobenzene	
Benzoic acid	Aroclor 1232	Chloroform	
Benzyl alcohol	Aroclor 1242	Chloromethane (methyl chloride)	
Beryllium and compounds	Aroclor 1248	Chrysene	
Bis(2-chloroethyl)ether	Aroclor 1254	Cobalt	
Bis(2-chloro-1-methylethyl) ether	Aroclor 1260	DDD	
Bis(2-ethylhexyl)phthalate	Atrazine	DDE, p,p'-	
Boron and borates only	Benzene	DDT	
Bromodichloromethane	Benzidine	Dibenz[*a,h*]anthracene	
Bromoform	Benz[*a*]anthracene	Dibenzofuran	
Bromomethane	Benzo[*a*]pyrene	Dieldrin	
2-Butanone (methyl ethyl ketone)	Benzo[*b*]fluoranthene	Dimethylphthalate	
Butyl benzyl phthalate	Benzo[*k*]fluoranthene	di-N-Octyl phthalate	
Cadmium (diet)	Benzyl alcohol	thylbenzene	
Carbazole	Bis(2-chloroethyl)ether	~Fluorene	
Carbofuran	Bis(2-ethylhexyl)phthalate	Hexachlorobenzene	
Carbon disulfide	Bromodichloromethane	Hexachlorobutadiene	
Carbon tetrachloride	Bromoform	Indeno[1,2,3-*cd*]pyrene	
Chlordane-alpha	Bromomethane	Isophorone	
Chlordane-beta	Butyl benzyl phthalate	Lead and compounds	
Chlordane-gamma	Carbon disulfide	Lithium	
4-Chloroaniline	Carbon tetrachloride	Mercury (elemental)	
Chlorobenzene	Chlordane-gamma	Naphthalene	
Ethyl chloride (chloroethane)			
Chloroform			

Table C-5. Surface Soil Chemical Constituent Screening Results by Constituent (continued)

All Constituents with PRGs[a]	Constituents Where EPA RSL < PRG[a]	Constituents Where EPA RSL < PRG (any EU)[a]	Constituents Where MDC > EPA RSL (any EU)[a]
Chloromethane (methyl chloride) 4-Chloro-3-methylphenol (Cresol, p-chloro-m-) 2-Chloronaphthalene (beta-) Chlorophenol, 2- Chlorpyrifos Chromium(III), insoluble salts Chromium(VI) Chrysene Cobalt Copper Cyanide (CN^-) Cyclohexane DDD DDE, p,p'- DDT Dalapon Demeton Dibenz[*a,h*]anthracene Dibenzofuran Dibromochloromethane 1,2-Dibromo-3-chloropropane Dibutyl phthalate Dicamba Dichlorobenzene, 1,2- Dichlorobenzene, 1,3- Dichlorobenzene, 1,4- Dichlorobenzidine, 3,3'- Dichlorodifluoromethane Dichloroethane, 1,1- Dichloroethane, 1,2- Dichloroethylene, 1,1- Dichloroethene, 1,2- (total) Dichlorophenol, 2,4- Dichlorophenoxy acetic acid, 2,4- Dichlorophenoxy)butyric acid, 4-(2,4- Dichloropropane, 1,2- Dichloropropane, 1,3- Dichloropropene, *cis*-1,3- Dichloropropene, *trans*-1,3- Dieldrin Diethyl ether (ethyl ether) Di(2-ethylhexyl)adipate Diethyl phthalate Dimethoate Dimethylphenol, 2,4- Dimethylphthalate Dinitro-o-cresol, 4,6- Dinitrophenol, 2,4- Dinitrotoluene, 2,4- Dinitrotoluene, 2,6- di-N-Octyl phthalate Dinoseb Dioxane, 1,4-	Chlorobenzene Chloroform Chloromethane (methyl chloride) Chlorpyrifos Chrysene Cobalt Cyanide (CN^-) Cyclohexane DDD DDE, p,p'- DDT Di(2-ethylhexyl)adipate Dibenz[*a,h*]anthracene Dibenzofuran Dibromochloromethane Dichlorodifluoromethane Dieldrin Dimethoate Dimethylphthalate di-N-Octyl phthalate Ethyl acetate Ethylbenzene Fluorene Heptachlor Hexachlorobenzene Hexachlorobutadiene Hexachlorocyclohexane, alpha- Hexachlorocyclohexane, beta- Hexachlorocyclohexane, gamma- (Lindane) Hexachlorocyclohexane, technical Hexachlorocyclopentadiene Hexachlorodibenzo-*p*-dioxin Hexachloroethane HxCDD, 1,2,3,6,7,8- HxCDD, 1,2,3,7,8,9- Indeno[1,2,3-*cd*]pyrene Isophorone Lead and compounds Lithium Mercury (elemental) Methyl methacrylate Methyl *tert*-butyl ether (MTBE) Mirex Naphthalene Nitrobenzene Nitrosodiethylamine, N- Nitrosodimethylamine, N- Nitroso-di-N-butylamine, N- Nitroso-di-*n*-propylamine, N- Nitrosodiphenylamine, N- Nitrosopyrrolidine, N- Pentachlorophenol	Nitroso-di-*n*-propylamine, N- Pentachlorophenol Styrene Thallium (soluble salts) Uranium (soluble salts)[b] Xylenes	

Table C-5. Surface Soil Chemical Constituent Screening Results by Constituent (continued)

All Constituents with PRGs[a]	Constituents Where EPA RSL < PRG[a]	Constituents Where EPA RSL < PRG (any EU)[a]	Constituents Where MDC > EPA RSL (any EU)[a]
TCDD, 2,3,7,8- Diphenylhydrazine, 1,2- Diquat Endosulfan I Endosulfan II Endosulfan sulfate Endosulfan (technical) Endrin Endrin aldehyde Endrin ketone Ethyl acetate Ethylbenzene Ethylene dibromide (Dibromoethane, 1,2-) Fluoranthene Fluorene Fluorine (soluble fluoride) Glyphosate Guthion (azinphos-methyl) Heptachlor Heptachlor epoxide Hexachlorobenzene Hexachlorobutadiene Hexachlorocyclohexane, alpha- Hexachlorocyclohexane, beta- Hexachlorocyclohexane, gamma- (Lindane) Hexachlorocyclohexane, delta- Hexachlorocyclohexane, technical Hexachlorocyclopentadiene Hexachlorodibenzo-*p*-dioxin HxCDD, 1,2,3,6,7,8- HxCDD, 1,2,3,7,8,9- Hexachloroethane Indeno[1,2,3-*cd*]pyrene Iron Isobutyl alcohol Isophorone Isopropylbenzene (cumene) Lead and compounds Lithium Manganese (diet) Mercury (elemental) Methoxychlor MCPA MCPP Methylene chloride Methyl methacrylate Methylnaphthalene, 2- Methyl isobutyl ketone (4-methyl-2-pentanone) 2-Methylphenol (cresol, *o*-) 4-Methylphenol (Cresol, *p*-) Methyl *tert*-butyl ether	*p*-Nitrotoluene, Simazine Styrene Thallium (soluble salts) Toxaphene Uranium (soluble salts)[b] Vinyl acetate Vinyl chloride Xylene, *m*- Xylene, *o*- Xylene, *p*- Xylenes		

Table C-5. Surface Soil Chemical Constituent Screening Results by Constituent (continued)

All Constituents with PRGs[a]	Constituents Where EPA RSL < PRG[a]	Constituents Where EPA RSL < PRG (any EU)[a]	Constituents Where MDC > EPA RSL (any EU)[a]
(MTBE) Mirex Molybdenum Naphthalene Nickel soluble salts Nitrate Nitrite Nitroaniline, 2- Nitroaniline, 4- Nitrobenzene Nitrophenol, 4- Nitroso-di-N-butylamine, N- Nitrosodiethylamine, N- Nitrosodimethylamine, N- Nitrosodiphenylamine, N- Nitroso-di-*n*-propylamine, N- Nitrosopyrrolidine, N- Nitrotoluene, p- Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) Oxamyl Parathion Pentachlorobenzene Pentachlorophenol Phenanthrene Phenol Picloram Pyrene Selenium Silver Simazine Strontium, stable Styrene Sulfide Tetrachlorobenzene, 1,2,4,5- Tetrachloroethane, 1,1,1,2- Tetrachloroethane, 1,1,2,2- Tetrachloroethylene Tetrachlorophenol, 2,3,4,6- Thallium (soluble salts) Tin Titanium Toluene Toxaphene Trichlorobenzene, 1,2,4- Trichloroethane, 1,1,1- Trichloroethane, 1,1,2- Trichloroethylene Trichlorofluoromethane Trichlorophenol, 2,4,5- Trichlorophenol, 2,4,6- Trichlorophenoxypropionic acid, -2,4,5 Trichloropropane, 1,2,3- Trichloro-1,2,2- Trifluoroethane, 1,1,2- Trinitrotoluene, 2,4,6- Uranium (soluble salts)[b]			

Table C-5. Surface Soil Chemical Constituent Screening Results by Constituent (continued)

All Constituents with PRGs[a]	Constituents Where EPA RSL < PRG[a]	Constituents Where EPA RSL < PRG (any EU)[a]	Constituents Where MDC > EPA RSL (any EU)[a]
Vanadium and compounds Vinyl acetate Vinyl chloride Xylene, *p*- Xylene, *m*- Xylene, *o*- Xylenes Zinc and compounds			

Notes:

[a] The first column lists all constituents for which WRW PRGs were developed. The constituents are arranged in the same order as they were in the CRA methodology document where the PRGs were developed (DOE 2004). The second column lists all constituents where the May 2016 EPA RSLs were lower than the WRW PRGs. The constituents are arranged in the order used in the PRG screening tables that were included in the CRA for each EU. That same order is used for subsequent columns. The third column includes all constituents that were carried through the screening process for any EU. The last column contains all constituents with an MDC that exceeded an EPA RSL. Note that arsenic and vanadium are not carried past the first column in this table because the EPA RSLs are greater than the WRW PRGs and rescreening isn't required.

[b] The revised risk-based screening level for uranium was calculated using the oral reference dose recommended in EPA's December 2016 memorandum (EPA 2016). This screening level is lower than that contained in EPA's current RSLs.

Because nNo COCs were identified in the CRA for subsurface soils, and bBecause the reevaluation of surface soil data discussed above indicated that the CRA process was sound in identifying COCs, it was decided that rescreening all PRGs against subsurface soil data was not warranted, a A more targeted approach was taken in this FYR to answer Question B with regard to subsurface soils by focusing on constituents that were most likely to be present in subsurface soils. An abbreviated PRG list was used for subsurface soil screening based on the results of the surface soil screening process. This included all constituents for which any surface soil MDC exceeded the surface soil PRG (constituents listed in Table C-4 and last column in Table C-5); tetrachloroethene was also added to this list as it was identified as a subsurface analyte of interest in the RI/FS (Table C-1). The constituents evaluated along with screening results are listed in Table C-6. Original subsurface soil PRGs were 11.5 times higher than surface soil PRGs because of the lower frequency of exposure (20 days versus 230 days) (DOE 2004). Therefore, Tthe current WRW RSLs were multiplied by 11.5 to obtain current estimates of subsurface WRW PRGs. The screening with this smaller set of PRGs proceeded in the same manner as the surface soil FYR evaluation described above.

Table C-6. Subsurface Soil Chemical Constituent Screening Results by EU

Constituent	Industrial Area EU	Upper Woman Drainage EU	Wind Blown EU	No Name Gulch EU	Upper Walnut Drainage EU	Lower Woman Drainage EU	Rock Creek EU	Lower Walnut Drainage EU	Inter Drainage EU	West Area EU	Southwest Buffer Zone Area EU	Southeast Buffer Zone Area EU
2,3,7,8-TCDD	-	-	-	-	-	-	-	-	-	-	-	-
Aroclor-1254	X	-	-	-	-	-	-	-	-	-	-	-
Aroclor-1260	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	X	-	-	-	-	-	-	-	-	-	-	-
Benzo[*a*]anthracene	-	X	-	-	-	-	-	-	-	-	-	-
Benzo[*a*]pyrene	X	X	X	-	-	-	-	-	-	-	-	-
Benzo[*b*]fluoranthene	-	X	-	-	-	-	-	-	-	-	-	-
Cobalt	-	X	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	X	-	-	-	-	-	-	-	-	-	-	-
Indeno[1,2,3-*cd*]pyrene	-	-	-	-	-	-	-	-	-	-	-	-
Lead and compounds	-	-	-	-	-	-	-	-	-	-	-	-
Mercury (elemental)	-	-	-	-	-	-	-	-	-	-	-	-
Naphthalene	X	-	-	-	-	-	-	-	-	-	-	-
N-Nitroso-di-*n*-propylamine	-	-	-	-	-	-	-	-	-	-	-	-
Tetrachloroethene	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	-	-	-	-	-	-	-	-	-	-	-	-
Uranium (soluble salts)	X	-	-	-	-	-	-	-	-	-	-	-

Notes:
Arsenic and vanadium were included in this table because these constituents were identified as COCs in the CRA and their 95UCL exceeds their WRW PRG.

Abbreviations:
2,3,7,8-TCDD = 2,3,7,8-tetrachlorodibenzo-*p*-dioxin
- = MDC < EPA RSL
X = MDC > EPA RSL

C2.3.2 Chemical Constituent Evaluation Results

Surface Soils. As was the case in the original comprehensive risk assessment screening process, nearly all constituents were eliminated in this FYR risk evaluation based on the MDC comparison screen. Despite the lower EPA RSLs, the MDCs were typically much lower than those screening values. Very few constituents were retained by the RSL screen that were not also retained by the PRG screen. Among these is uranium, for which EPA has recently recommended a much lower toxicity value (EPA 2016). Most constituents passing the RSL screen were subsequently eliminated based on the 95UCL comparison or following additional evaluation (e.g., frequency of detection <5%). Of the constituents evaluated in this FYR evaluation

screening process, only four constituents passed through the 95UCL screen. These are summarized in Table C-7.

Table C-7. Chemical Constituents and EUs where 95UCL Exceeds Current Screening Level

	Exposure Unit											
Constituent	**Industrial Area EU**	**Upper Woman Drainage EU**	**Wind Blown EU**	**No Name Gulch EU**	**Upper Walnut Drainage EU**	**Lower Woman Drainage EU**	**Rock Creek EU**	**Lower Walnut Drainage EU**	**Inter Drainage EU**	**West Area EU**	**Southwest Buffer Zone Area EU**	**Southeast Buffer Zone Area EU**
Arsenic	X	-	X	-	-	-	-	-	-	-	-	-
Vanadium	-	-	-		-	-	-	-	-	-	-	-
2,3,7,8-TCDD		X	-	-	-	-	-	-	-	-	-	-
Benzo[*a*]pyrene	X	X	-	X	X	-	-	-	-	-	-	-
Dibenz[*a,h*]anthracene	-	X	-	-	-	-	-	-	-	-	-	-

Notes:
Shaded boxes differ from the CRA results.

Abbreviations:
2,3,7,8-TCDD = 2,3,7,8-tetrachlorodibenzo-*p*-dioxin
- = constituent not considered a COC in CRA.
X = constituent would be considered a COC based on CRA screening methodology

As in the original comprehensive risk assessment, dioxin was identified as a COC for the Upper Woman Drainage EU and benzo[*a*]pyrene as a COC for the Industrial Area EU, Upper Woman Drainage EU, and the Upper Walnut Drainage EU. Based on the rescreening process, benzo[*a*]pyrene would also be considered a COC for the No Name Gulch EU, with concentrations slightly above the current RSL. The rescreening process also confirmed that arsenic is still considered a COC for the Industrial Area EU and Wind Blown EU based on current RSL concentrations; estimated risk levels associated with residual arsenic would be similar to that in the CRA. The arsenic 95UCL for all the other EUs also exceeded the PRG (and the current RSL) but arsenic was eliminated as a COC for those EUs in the CRA based on subsequent screens. Based on the current vanadium RSL, vanadium would not be a COC. The vanadium PRG is based on a lower toxicity value than is currently being used by EPA; however, vanadium is still undergoing study and this value could change in the future. As in the CRA, dibenz[*a,h*]anthracene did pass through the 95UCL screen for the Upper Woman Drainage EU; however, the frequency of detection was less than 5% for this constituent, and it was eliminated on that basis. For the most part, the rescreening process confirmed the results of the CRA for surface soils.

Subsurface Soils. The MDCs for a number of constituents exceeded the updated WRW RSLs. However, all constituents dropped out based on the 95UCL screen, and the reevaluation confirmed that there are no subsurface COCs.

The vapor intrusion pathway was identified in the CRA as a potentially complete pathway for VOCs in subsurface soils, including those at depths greater than 8 feet. Most of the AOIs

identified for subsurface soils in the RI/FS Report are VOCs (Table C-1). EPA has finalized guidance for evaluating the vapor intrusion pathway (EPA 2015) and provided guidance for evaluating this pathway in five-year reviews (EPA 2012b). Updated toxicity data are also available for some VOCs that are identified as AOIs at subsurface depths greater than 8 feet (e.g., tetrachloroethene and trichloroethene). However, institutional controls are in place at the COU that eliminate the vapor intrusion pathway by prohibiting the construction of habitable structures. Remedial action objectives (RAOs) and cleanup goals remain valid and are not affected by updated guidance and toxicity data as long as institutional controls remain in place.

In addition to the toxicity values discussed above, EPA is reviewing the toxicity of two COCs for the COU, arsenic and benzo[*a*]pyrene. The arsenic study suggests that current methods of estimating risks from arsenic due to soil ingestion likely overestimate actual risks. The EPA study of benzo[*a*]pyrene (EPA 2014) is not yet completed, and results cannot be cited at this time. Changes in slope factors may be forthcoming, but are not yet available. None of these additional ongoing studies are anticipated to affect the protectiveness of the remedy.

C2.3.3 Radiological Constituent Review Methodology

As various scientific radiological organizations and communities (e.g., Center for Radiation Protection Knowledge, International Commission on Radiological Protection [ICRP], and EPA Federal Guidance Reports [FGRs]) gain greater knowledge of the effects of ionizing radiation on humans, changes are made to their supporting and guidance documents that are then used in radiological risk and dose calculation tools, such as the online EPA PRG calculator and the RESRAD dose model.

~~Information from t~~The current EPA online PRG calculator was used in this FYR radiological risk ~~evaluation~~ review to determine if the risks from radionuclides to the WRW in the COU remain within the acceptable CERCLA risk range (i.e., 1×10^{-4} to 1×10^{-6}). ~~Information in t~~The online PRG calculator incorporates the numerous changes to toxicity factors that have occurred since 2006, including revisions specific to Puplutonium and U~~uranium~~. In fact, 18 revisions have been made to the PRG calculator since 2001. In September 2014, a significant revision was adopted that follows EPA recommendations concerning the use of exposure parameters from the EPA *Exposure Factors Handbook* (EPA 2011). New slope factors for radionuclides have been programmed into the calculator that were derived following Federal Guidance Reports 12 and 13 using the updated isotope list from ICRP107. The cancer slope factors used by the PRG calculator are provided by the Center for Radiation Protection Knowledge. Examples of some of the slope factors used in the CRA (2006) compared to those found in the current EPA PRG calculator (2017) are shown in Table C-8.

~~Information from the current EPA PRG calculator was used in this FYR evaluation to determine if the risk from radionuclides to the WRW in the COU remains within the acceptable CERCLA risk range.~~ To perform the FYR review~~radiological risk evaluation~~, the input parameters used in the 2006 CRA for the WRW were entered into ~~used along with information from~~ the current online EPA PRG calculator to obtain updated PRG values that correspond to~~represent~~ risk levels within the acceptable EPA risk range (1×10^{-4} to a 1×10^{-6} ~~level of risk~~). These updated PRG values were then compared to the WRW PRG values from the 2006 CRA. For completeness, this FYR considered $^{239/240}$Pu (the only radionuclide COC identified in the 2006 CRA), ^{241}Am, ^{234}U,

^{235}U, and ^{238}U. The Amamericium and Uuranium isotopes represent the other primary radionuclides associated with RFP historical operations.

The CAD/ROD determination of risk level was based on a comparison of measured concentrations to target risk levels calculated in the CRA for WRW and WRV scenarios. Theis methodology used for this FYR review does not require input of site-specific analytical data because PRGs represent concentrations based on a target risk level rather than a calculated risk due to measured concentrations. As such, no new soil analytical data were collected for this FYR risk evaluationreview. Changes in PRG values (from 2006 to 2017) are the result of changes made to either the calculators and how ithey functions (e.g., formulas used in the calculations process have been modified/updated) or the scientific data that the calculators uses to compute risk (e.g., isotopic cancer slope factors or DCFs), or a combination of both.

Table C-8.Comparison of Slope Factors for Various Pathways

Isotope	1994[a]	2006	2017
	Adult Ingestion		
^{241}Am	2.40×10^{-10}	9.1×10^{-11}	9.1×10^{-11}
^{239}Pu	2.30×10^{-10}	1.21×10^{-10}	1.21×10^{-10}
^{234}U	1.60×10^{-11}	5.11×10^{-11}	5.11×10^{-11}
^{235}U	1.60×10^{-11}	4.92×10^{-11}	4.92×10^{-11}
^{238}U	1.60×10^{-11}	4.66×10^{-11}	4.66×10^{-11}
	Adult Inhalation		
^{241}Am	3.20×10^{-8}	2.81×10^{-8}	3.77×10^{-8}
^{239}Pu	3.80×10^{-8}	3.33×10^{-8}	5.55×10^{-8}
^{234}U	2.60×10^{-8}	1.14×10^{-8}	2.78×10^{-8}
^{235}U	2.50×10^{-8}	1.01×10^{-8}	2.50×10^{-8}
^{238}U	2.40×10^{-8}	9.32×10^{-9}	2.36×10^{-8}
	Adult External Exposure		
^{241}Am	4.90×10^{-9}	2.76×10^{-8}	2.77×10^{-8}
^{239}Pu	1.70×10^{-11}	2.00×10^{-10}	2.09×10^{-10}
^{234}U	3.00×10^{-11}	2.52×10^{-10}	2.53×10^{-10}
^{235}U	2.40×10^{-7}	5.18×10^{-7}	5.51×10^{-7}
^{238}U	2.10×10^{-11}	4.99×10^{-11}	1.24×10^{-10}

[a] DOE 1994.

Limitations on Use of the EPA PRG Calculator. During the review/recalculation process, it was noted that the current online PRG calculator requires additional information that was not used in the 2006 PRG calculations and, thus, not available for input. While the EPA PRG calculator contains default values for all of these additional inputs, it was determined that the use of default values would create an entirely new scenario, distinct from that evaluated in 2006. The resulting comparison of these updated PRGs calculated by the PRG calculator to the 2006 PRGs would not be appropriate or meaningful. To address this issue, updated PRG values were calculated using a Microsoft Excel spreadsheet (or Excel calculator) created to run the various applicable formulas found in the current EPA PRG calculator. Significant effort was taken to accurately recalculate PRG values using the 2006 and earlier data sets, by checking the results of the Excel

~~spreadsheet against known values. Risk slope factors from the online 2017 EPA PRG calculator, as well as decay constants of the isotopes being used in the calculation, are used by the Excel calculator to calculate current (2017) PRG values. Calculations performed in the Excel spreadsheet did not take into account progeny from the parent isotopes, similar to what occurs in the EPA PRG calculator. Verification of the Excel spreadsheet calculator was performed using available data inputs from the 2006 CRA taken from the 2004 CRA methodology document (DOE 2004), the 2002 radionuclide soil action levels used during accelerated remedial actions in the COU (DOE, EPA and CDPHE 2002), and the programmatic PRGs calculated in 1994 for the OU3 baseline risk assessment (DOE 1994).~~

C2.3.4 Radionuclide Constituent Evaluation Results

Table C-9 contains the PRG comparison results for the WRW in the COU. As shown in the table, the 2017 PRGs calculated ~~values~~ for ^{241}Am and ^{235}U at the 1 x 10^{-6} risk level ~~each radionuclide~~ are less conservative (i.e., larger) than the PRGs calculated in 2006 at the same risk level. The 2017 PRGs calculated for ^{239}Pu, ^{240}Pu, ^{234}U, and ^{238}U are slightly more conservative (i.e., smaller) than the PRGs calculated in 2006 at the 1 x 10^{-6} risk level. The largest decrease in PRGs for any radionuclide is ^{238}U, which decreased from 29.3 pCi/g to 22.9 pCi/g, a difference of 6.4 pCi/g. The decrease in calculated PRGs from 2006 for ^{239}Pu, ^{240}Pu, ^{234}U, and ^{238}U is most likely attributed to the revision of the Pu and U slope factors adopted by EPA since 2006 (see Table C-8). Although the calculated risk associated with these four radionuclides increased slightly, the risk remains on the higher end (i.e., most protective) of the risk range, between 1 x 10^{-5} and 1 x 10^{-6}. ~~Therefore, even though changes have occurred to various toxicity factors and other risk input since 2006,~~ In summary, the calculated risk to a WRW ~~remedy in~~ the COU remains within the acceptable risk range considered by EPA to be protective of human health and therefore, the remedy in the COU remains protective.

Table C-~~9~~9. PRG Comparison for WRW[a] ~~in the COU (pCi/g at 10^{-6} risk level)~~

Isotope	2006 CRA PRG[b] (pCi/g)	2017 PRG (pCi/g) 2017 PRG		
Risk Level	1 x 10^{-6}	1 x 10^{-4}	1 x 10^{-5}	1 x 10^{-6}
^{241}Am	7.69	1150	115	~~8.81~~11.5
^{239}Pu	9.78	929	92.9	~~11.85~~9.29
^{240}Pu	9.80	931	93.1	9.31
^{234}U	25.3~~4~~	2000	200	~~29.96~~20.0
^{235}U	1.05	454	45.4	~~1.06~~4.54
^{238}U	29.3~~3~~	2290	229	~~34.38~~22.9

[a] The calculated risk to a Wildlife Refuge Visitor (WRV) in the COU is less than the calculated risk to a WRW, primarily due to the difference in exposure frequency. The WRW scenario exposure frequency for an adult is 230 days/year; the WRV scenario exposure frequency for an adult is 250 hours/year.

[b] DOE 2004

C2.3.5 Radiological Dose Assessment Review

In addition to human health risk calculations performed in the comprehensive risk assessment, a radiation dose assessment for exposure to residual radionuclide contamination in surface soil and subsurface soil was also completed. The purpose of the dose assessment was to demonstrate compliance with the annual dose limits in Colorado Radiation Control Regulations (Volume 6 *Code of Colorado Regulations* Regulation 1007-1, Part 4 [6 CCR 1007-1, Part 4]), which were identified as Applicable Relevant and Appropriate Requirements (ARARs) in the Corrective Action Document/Record of Decision (CAD/ROD) (DOE 2006). For radiological sites that do not allow for unrestricted use, as is the case for the COU, Colorado regulations require that institutional controls be in place that reasonably ensure that the total effective dose equivalent from residual radioactivity at the site does not exceed 25 mrem/year (6 CCR 1007-4.61.2).

RESRAD-ONSITE is a pathway analysis computer code that calculates radiation doses and cancer risks to a critical population group and can be used to derive cleanup criteria for radioactively contaminated soils. Since 2002, eight revisions have been made to RESRAD-ONSITE (RESRAD). In 2014, RESRAD was revised to allow dose conversion factor database and software capability for ICRP107. In 2016, RESRAD was revised to provide options to choose between the ICRP38 radionuclide decay database and the ICRP107 radionuclide decay database; ICRP38 supports the use of either ICRP26/30- or ICRP60/72-based dose coefficients, and ICRP107 supports the use of ICRP60-based dose coefficients from DCFPAK 3.02. A comparison of the RESRAD version 6.3 dose results to the RESRAD version 7.2 dose results indicates little change in total dose (see Table C-12).

Changes to ICRP Versions. Within the RESRAD-ONSITE Computer Code (Revision 7.2, July 20, 2017), both DCFs and slope factors are used. For the verification calculations performed in 2017, the program was first set to use ICRP38 for radionuclide transformations. This configuration defaults to ICRP72 (selectable from adult to infant) for the internal dose library, ICRP60 for the external dose library, and FGR13 morbidity risk factors (Figure C-3). The ICRP38 configuration best approximates the older 2006 (Revision 6.3) version of the calculator that was used in 2006, as ICRP38 was replaced by ICRP107 in 2008 in the software program. Then the calculator was set to use ICRP107 for radionuclide transformations. This configuration defaults to U.S. Department of Energy (DOE) STD-1196-2001 Reference Person (selectable from adult to infant) for the internal dose library, DCFPAK 3.02 for the external dose library, and DCFPAK 3.02 morbidity risk factors (Figure C-4). *Oak Ridge National Laboratory, Calculation of Slope Factors and Dose Coefficients, September 2014* (https://epa-prgs.ornl.gov/radionuclides/SlopesandDosesFinal.pdf) provides detailed information regarding the development of the risk factors and dosees coefficients used in the current RESRAD-ONSITE software program. Both the ICRP38 and ICRP107 versions of the RESRAD-ONSITE calculator were run (using the 2006~~old~~ data), to provide an understanding of the revisions to the RESRAD-ONSITE calculator, based on the results of the calculator runs.

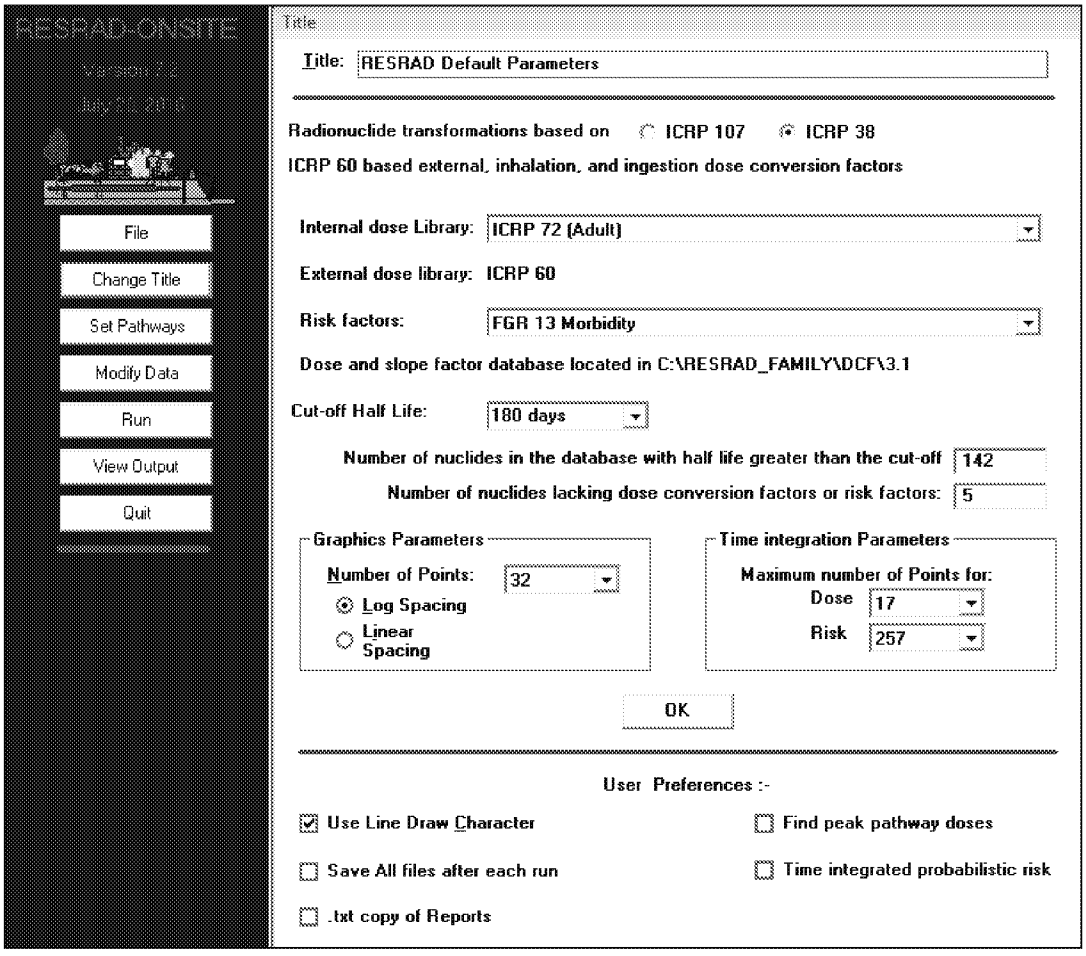

Figure C-3. RESRAD-ONSITE Title Screen, ICRP 38

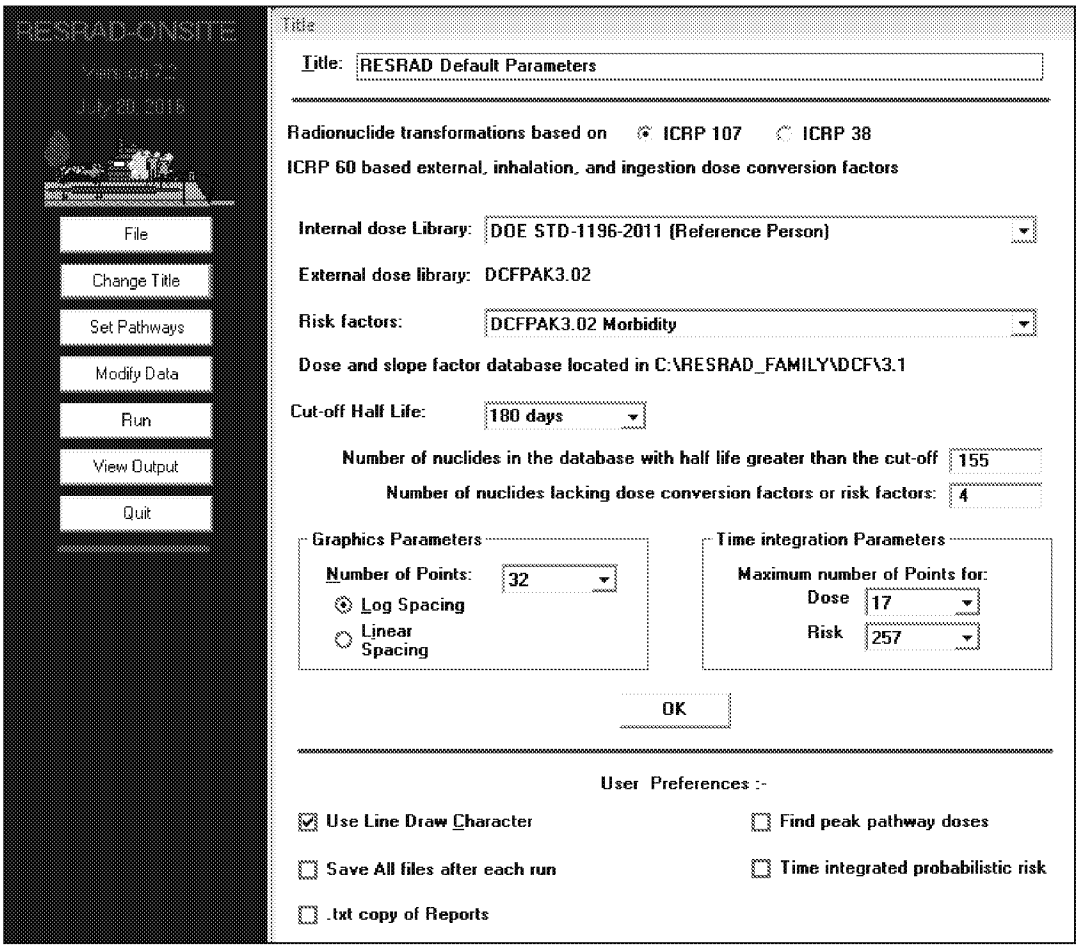

Figure C-4. RESRAD-ONSITE Title Screen, ICRP 107

Changes to Dose Conversion Factors. RESRAD-ONSITE dose conversion factors were evaluated for changes between the 2006 and 2017 software program (versions 6.3 and 7.2 and ICRP38 and ICRP107, respectively). Only the key isotopes (those input in the calculator for the modeling runs performed in both 2006 and 2017, ^{241}Am, ^{239}Pu, ^{234}U, ^{235}U, and ^{238}U) were evaluated, as progeny isotope DCF values would likely follow suit of the parent isotope.

As shown in Tables C-10 and C-11, most DCF values for the inhalation and ingestion pathways changed between the 2006 and 2017 calculator versions for the parent and progeny isotopes. Shaded cells in the tables are the key isotopes (^{239}Pu, ^{241}Am) that were input into the calculators. Nonshaded table cells are isotopes that are introduced by the RESRAD-ONSITE calculator as a result of progeny ingrowth during the 1000-year evaluation time period. While those added isotopes add little value to the comparison aspect of the review, they represent the various DCFs for the radionuclides that in-grow over the 1000-year evaluation time period.

Table C-10. RESRAD Dose Conversion Factors (2006 and 2017, Am and Pu, Adult)

DCFs for Inhalation (mrem/pCi)					
Menu Code	**Parameter Isotope[a]**	**2006 ICRP72 Value**	**2017 ICRP38 Value**	**2017 ICRP107 Value**	**Parameter Name**
B-1	^{227}Ac+D	6.724×10^{0}	2.104×10^{0}	6.714×10^{-1}	DCF2(1)
	^{241}Am	1.600×10^{-1}	3.552×10^{-1}	3.630×10^{-1}	DCF2(2)
	^{237}Np+D	5.400×10^{-1}	1.850×10^{-1}	1.869×10^{-1}	DCF2(3)
	^{231}Pa	1.280×10^{0}	5.180×10^{-1}	8.769×10^{-1}	DCF2(4)
	^{239}Pu	1.900×10^{-1}	4.440×10^{-1}	4.477×10^{-1}	DCF2(5)
	^{229}Th+D	2.169×10^{0}	9.481×10^{-1}	9.865×10^{-1}	DCF2(6)
	^{233}U	1.350×10^{-1}	3.552×10^{-2}	3.811×10^{-2}	DCF2(7)
	^{235}U+D	1.100×10^{-2}	3.145×10^{-2}	3.378×10^{-2}	DCF2(8)
DCFs for Ingestion (mrem/pCi)					
Menu Code	**Parameter Isotope[a]**	**2006 ICRP72 Value**	**2017 ICRP38 Value**	**2017 ICRP107 Value**	**Parameter Name**
D-1	^{227}Ac+D	1.480×10^{-2}	4.473×10^{-3}	2.308×10^{-3}	DCF3(1)
	^{241}Am	7.400×10^{-4}	7.400×10^{-4}	8.806×10^{-4}	DCF3(2)
	^{237}Np+D	4.444×10^{-3}	4.102×10^{-4}	4.674×10^{-4}	DCF3(3)
	^{231}Pa	1.060×10^{-2}	2.627×10^{-3}	2.068×10^{-3}	DCF3(4)
	^{239}Pu	9.300×10^{-4}	9.250×10^{-4}	1.066×10^{-3}	DCF3(5)
	^{229}Th+D	4.027×10^{-3}	2.269×10^{-3}	3.329×10^{-3}	DCF3(6)
	^{233}U	2.890×10^{-4}	1.887×10^{-4}	2.227×10^{-4}	DCF3(7)
	^{235}U+D	1.713×10^{-4}	1.752×10^{-4}	2.048×10^{-4}	DCF3(8)

[a] Nonshaded table cells are isotopes that are introduced by the RESRAD-ONSITE calculator as a result of progeny ingrowth during the 1000-year evaluation time period.
+D = includes daughters (i.e., progeny)

Table C-11. RESRAD Dose Conversion Factors (2006 and 2017, U, Adult)

DCFs for Inhalation (mrem/pCi)					
Menu Code	**Parameter Isotope[a]**	**2006 ICRP72 Value**	**2017 ICRP38 Value**	**2017 ICRP107 Value**	**Parameter Name**
B-1	^{227}Ac+D	6.724×10^{0}	2.104×10^{0}	6.714×10^{-1}	DCF2(1)
	^{231}Pa	1.280×10^{0}	5.180×10^{-1}	8.769×10^{-1}	DCF2(2)
	^{210}Pb+D	2.320×10^{-2}	3.697×10^{-2}	4.017×10^{-2}	DCF2(3)
	^{226}Ra+D	8.594×10^{-3}	3.526×10^{-2}	3.823×10^{-2}	DCF2(4)
	^{230}Th	3.260×10^{-1}	3.700×10^{-1}	3.848×10^{-1}	DCF2(5)
	^{234}U	1.300×10^{-2}	3.478×10^{-2}	3.737×10^{-2}	DCF2(6)
	^{235}U+D	1.100×10^{-2}	3.145×10^{-2}	3.378×10^{-2}	DCF2(7)
	^{238}U	1.060×10^{-2}	2.960×10^{-2}	3.212×10^{-2}	DCF2(8)
	^{238}U+D	1.063×10^{-2}	2.963×10^{-2}	3.215×10^{-2}	DCF2(9)
DCFs for Ingestion (mrem/pCi)					
Menu Code	**Parameter Isotope[a]**	**2006 ICRP72 Value**	**2017 ICRP38 Value**	**2017 ICRP107 Value**	**Parameter Name**
D-1	^{227}Ac+D	1.480×10^{-2}	4.473×10^{-3}	2.308×10^{-3}	DCF3(1)
	^{231}Pa	1.060×10^{-2}	2.627×10^{-3}	2.068×10^{-3}	DCF3(2)
	^{210}Pb+D	7.276×10^{-3}	6.998×10^{-3}	1.026×10^{-2}	DCF3(3)
	^{226}Ra+D	1.321×10^{-3}	1.037×10^{-3}	1.677×10^{-3}	DCF3(4)
	^{230}Th	5.480×10^{-4}	7.770×10^{-4}	9.361×10^{-4}	DCF3(5)
	^{234}U	1.800×10^{-4}	1.813×10^{-4}	2.150×10^{-4}	DCF3(6)
	^{235}U+D	1.713×10^{-4}	1.752×10^{-4}	2.048×10^{-4}	DCF3(7)
	^{238}U	1.700×10^{-4}	1.665×10^{-4}	1.939×10^{-4}	DCF3(8)
	^{238}U+D	1.837×10^{-4}	1.791×10^{-4}	2.112×10^{-4}	DCF3(9)

[a] Nonshaded table cells are isotopes that are introduced by the RESRAD-ONSITE calculator as a result of progeny ingrowth during the 1000-year evaluation time period.
+D = includes daughters

~~As a result of changes made between the 2006 and 2017 RESRAD calculator versions, with regard to being able to select a child's age in the 2017 calculator version (e.g., infant, 1 year old, 5 years old, 10 years old, 15 years old), there were significant differences in the results of the RESRAD-ONSITE runs performed during the review, selecting different ages for each run. Therefore, a comparison of DCFs for non-adults was not performed and is not presented in the tables above.~~

Notes

For information not available/provided in the 2006 RESRAD result data sheets, 2017 RESRAD-ONSITE calculator default values were used~~the reviewer used 2017 RESRAD-ONSITE calculator default values~~.

For Child Surface Soil Am and Pu, Solar Ponds Revision 7.2, the RESRAD-ONSITE internal dose library allows for the selection of an age range of the child's age (unlike 2006) for use in a given scenario (five non-adult choices of age). ~~The reviewer used~~ "Age 1" was used as the

scenario input for the 2017 recalculation. The "Age" input section is very sensitive to the calculation result, so results varied significantly (11.5–0.778 mrem) as age selection was varied. The "older" ages (10 and 15) result in relatively smaller doses at time zero (the time of the largest dose to the individual). The 2006 Child scenarios reviewed identified "child" as the selection, and not "infant." The reviewer followed suit and elected not to use the "infant" option for the Age input selection.

C2.3.6 Dose Assessment Review Results

The dose assessment completed in 2006 used version 6.3 of the RESRAD computer code to calculate radiation doses to a scenario-driven critical population within the COU. The input parameters used in 2006 were entered into the most recent version of RESRAD (version 7.2) to calculate dose. The results of these 2006 calculations were compared to the current version of RESRAD (version 7.2) results, allowing the reviewer the ability to compare past RESRAD calculation results to current results. This comparison can then be used to better understand if changes in the results are occurring, and if occurring, to what magnitude. Note that a new dose was not calculated for the COU in this evaluation. No new sample data were collected to support this fourth FYR dose evaluation. Instead, the same input parameters and analytical data values used in 2006 were entered into the most recent RESRAD version to determine the relative impact of changes to the computer code.

In order to understand the relatively minor impact to dose resulting from the numerous changes to input parameters and the computer model that have occurred since 2006, a range of exposure scenarios and associated analytical data evaluated in the 2006 RESRAD (version 6.3) dose assessment was entered into the current RESRAD model (version 7.2). Four existing 2006 scenarios were selected to review and recalculate total dose: (1) resident adult exposure to ^{239}Pu-~~239~~ and Am in subsurface soil in the Ash Pits East area, (2) resident child exposure to ^{239}Pu-~~239~~ and Am in surface soil at the Solar Evaporation Ponds, (3) WRW exposure to Uuranium~~ium~~ in subsurface soil at the Wind Blown area, and (4) WRW exposure to Uuranium~~ium~~ in surface soil at the Wind Blown area. This semi-random selection of scenarios was slightly bias-based to include a mix of radionuclides (^{241}Am, ^{239}Pu, ^{234}U, ^{235}U, and ^{238}U), both adult and child scenarios, and three different locations with surface and subsurface impacts/potential impacts in different OUs (COU and POU). Table C-12 presents the 2006 RESRAD scenario calculation results for the four scenarios, the 2017 RESRAD-ONSITE scenario calculation results using ICRP 38, and the 2017 RESRAD-ONSITE results using ICRP107.

A comparison of the RESRAD version 6.3 dose results to the RESRAD version 7.2 dose results indicates little change in total dose (Table C-12). Each of the 2006 scenarios evaluated yielded similar results, suggesting that the changes in total dose for all scenarios and locations evaluated in 2006 would be negligible using the current RESRAD model version. This simply means that the changes to RESRAD since 2006 have not resulted in major impacts to dose calculated by the model. That is, the dose calculated using RESRAD version 6.3 is nearly the same as the dose calculated using RESRAD version 7.2, given the same site-specific input parameters used in 2006. Therefore, because the dose assessment from 2006 indicated that the lands within the COU are in compliance with the dose criteria ARAR from the CAD/ROD with a total dose much less than 25 mrem/year, a recalculation of dose using the most updated version of RESRAD ~~would~~ yields the same results, and the ARAR would still be met. As a result, this FYR dose assessment

evaluation ~~concludes~~ shows that the dose criteria ARAR continues to be met and supports the conclusion that the remedy in the COU remains protective.

Table C-12. RESRAD Scenario Calculation Results (2006 and 2017)

RESRAD Scenario Identification	Maximum Total Dose (mrem/year)
2006 Resident Adult Subsurface Soil Am and Pu Ash Pits East	8.918×10^{-4}
2017 Resident Adult Subsurface Soil Am and Pu Ash Pits East (ICRP38)	8.986×10^{-4}
2017 Resident Adult Subsurface Soil Am and Pu Ash Pits East (ICRP107)	9.893×10^{-4}
2006 Resident Child Surface Soil Am and Pu Solar Ponds	1.499×10^{0}
2017 Resident Child Surface Soil Am and Pu Solar Ponds (ICRP38)	1.351×10^{0}
2017 Resident Child Surface Soil Am and Pu Solar Ponds (ICRP107)	1.361×10^{0}
2006 WRW Subsurface Wind Blown U	8.499×10^{-3}
2017 WRW Subsurface Wind Blown U (ICRP38)	8.682×10^{-3}
2017 WRW Subsurface Wind Blown U (ICRP107)	9.259×10^{-3}
2006 WRW Surface Wind Blown U	8.029×10^{-2}
2017 WRW Surface Wind Blown U (ICRP38)	8.226×10^{-2}
2017 WRW Surface Wind Blown U (ICRP107)	8.818×10^{-2}

C3.0 POU

The chemical and radiological risks associated with the POU were evaluated as part of the 2006 comprehensive risk assessment (DOE 2006). A radiological dose assessment using the RESRAD computer code was also completed. The POU and OU3 (discussed in Section C4.0) were determined to be suitable for UU/UE and were deleted from the NPL in 2007 (72 FR 29276). Because conditions at these two OUs were determined to meet the criteria for UU/UE, a FYR of these OUs is not required. However, the continued applicability of UU/UE for these OUs was reviewed in light of potential changes to toxicity factors and other risk-related information since the original UU/UE determinations were made. The conclusions from these reviews are discussed in this section for the POU and in Section C4.0 for OU3.

C3.1 Chemical Constituents Evaluation

The chemical review of the UU/UE criteria for the POU utilized a similar approach as the COU chemical risk evaluation. The rural resident soil action levels calculated in 2002 were compared to the EPA 2016 residential RSL table values (most recent values available). All 2016 RSLs that were lower than the 2002 values (i.e., were more conservative) were retained for comparison against residual POU surface soil concentrations from the 2006 CRA dataset (Table C-13). All residual surface soil concentrations correspond to levels within or below the CERCLA acceptable risk range (1×10^{-4} to 1×10^{-6}) based on the updated residential RSLs. It is therefore confirmed that the POU is still suitable for UU/UE.

Table C-13. 2016 Residential RSLs and POU Surface Soil Concentrations

Constituent	2016 Residential RSLs (µg/kg)		Range of Concentrations Detected in POU Surface Soils (µg/kg)
Risk Level	1×10^{-4}	1×10^{-6}	
2,6-Dinitrotoluene	36,000	360	170–550
Benzo[*a*]anthracene	16,000	160	170–550
Benzo[*a*]pyrene	1600	16	170–1000
Benzo[*b*]fluoranthene	16,000	160	170–550
Bis(2-chloroethyl)ether	23,000	230	170–550
Bis(2-chloroisopropyl)ether	8600	86	170–550
Dibenz[*a,h*]anthracene	1600	16	170–550
Hexachlorobenzene	21,000	210	170–550
Indeno[1,2,3-*cd*]pyrene	16,000	160	170–550
N-Nitroso-di-*n*-propylamine	7800	78	170–550
Aroclor-1254	3,800[a]	120[a]	80–260
Pentachlorophenol	100,000	1000	850–2650

Note:
[a] Upper screening level based on HQ = 1.

Abbreviation:
µg/kg = micrograms per kilogram

C3.2 Radiological Constituents Evaluation

The radiological review of the UU/UE criteria for the POU utilized the same approach as~~used for~~ the COU radiological review~~risk evaluation~~. The ~~2017~~ EPA online calculator was used to generate 2017 ~~site-specific~~ PRGs for the POU based on the~~a~~ residential scenario evaluated in the 2006 CAD/ROD. These PRGs ~~that~~ were then compared to the rural resident PRGs calculated in 2002, ~~assuming the same data inputs~~. As with each of the risk reviews completed for this FYR report, no new soil analytical data were collected. The site-specific input parameters for the POU risk review were taken from the 2002 Radionuclide Soil Action Levels report (DOE, EPA, and CDPHE 2002) and are presented in Figure x-x. It was necessary to use the input parameters from this report because, unlike the 2006 CRA, the 2002 report included evaluation of a rural resident scenario, which is appropriate for the UU/UE evaluation.

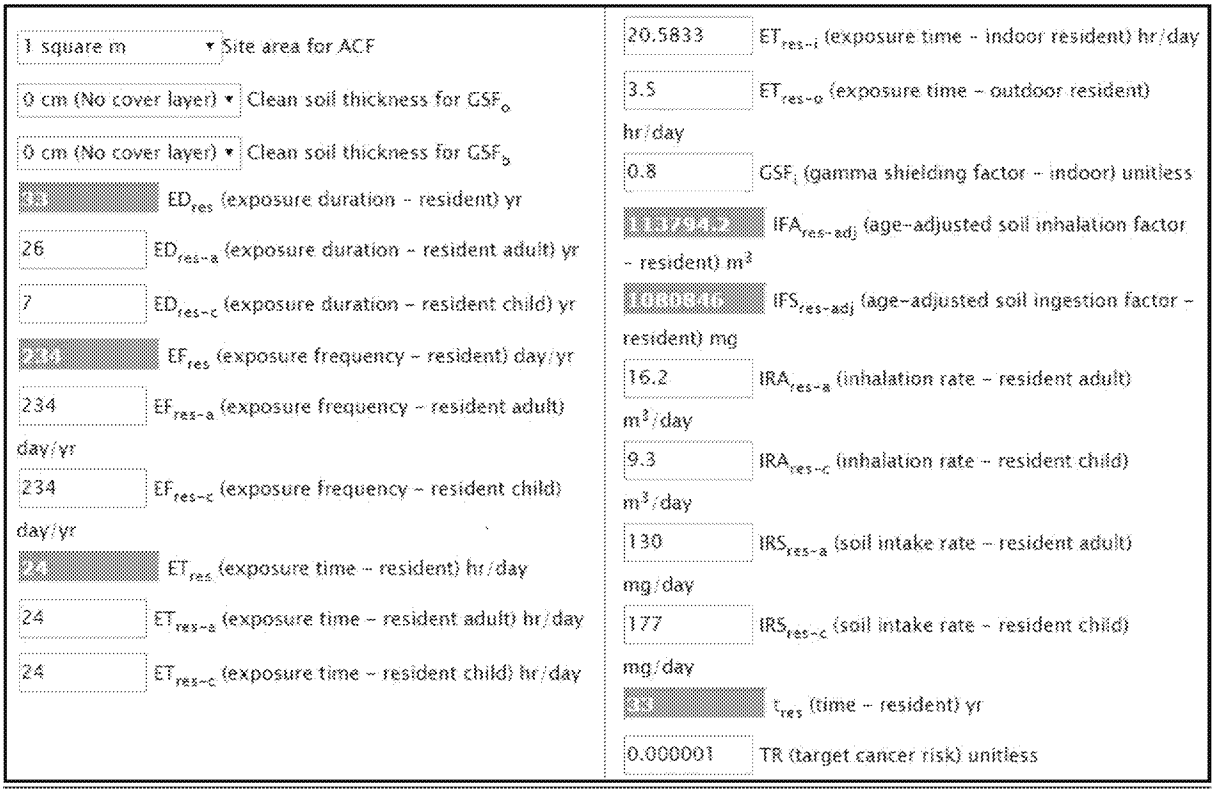

Figure x-x 2002 Site-Specific Input Values

Table C-14 presents the results of the POU UU/UE review. Although the only COCs identified in the POU were $^{239/240}$Pu ~~239/240~~ and ^{241}Am ~~241~~, the U isotopes were included in order to be consistent with the COU and OU3 reviews. As shown in the table, the 2017 PRGs for ^{241}Am ~~241~~, ^{239}Pu ~~239~~, ^{234}U ~~234~~, and ^{238}U ~~238~~ at a risk level of 1×10^{-6} are lower than those calculated in 2002 at the same risk level. ~~This means that the overall risk from these radionuclides has increased as a result of changes in toxicity factors and/or formulas adopted since 2002.~~ The changes in the PRGs for ^{239}Pu ~~239~~ are significant across the risk range (1×10^{-4} to 1×10^{-6}), which indicates that the calculated risk associated with ^{239}Pu ~~239~~ for the rural resident has increased since 2002. To provide perspective, the MDC of ^{239}Pu ~~239~~ in the POU in 2006 was approximately 20 pCi/g (DOE, EPA, CDPHE 2006). This equates to a risk between 1×10^{-4} and 1×10^{-5} when compared to the 2017 PRG values. While this risk is closer to the higher end of the risk range (i.e., less protective), it is still within the EPA acceptable risk range considered by EPA to be protective of human health ~~the acceptable risk range~~. Based on this FYR radiological review, the POU continues to meet the criteria for UU/UE.

A comparison of 2017 PRGs for the COU (Table C-9) and the POU (Table C-14) shows that the calculated PRGs decreased from the original PRGs for ^{239}Pu, ^{234}U, ^{238}U in both the WRW and rural resident scenarios. The PRGs for ^{241}Am and ^{235}U increased from the original PRGs using the WRW scenario in the COU and decreased from the original PRGs using the rural resident scenario in the POU. The decreases in the PRGs are attributed to the revision of slope factors for Pu and U that were adopted by EPA over the years since the original PRGs were calculated. In addition, differences in the exposure pathways inherent to the WRW and rural resident scenarios also impact the PRG calculations. For example, the WRW scenario does not include exposure pathways for the ingestion of vegetables, whereas the rural resident scenario does include this

pathway. Thus, because the rural resident is potentially exposed to site contaminants through more pathways than the WRW, the PRG value to protect the resident must be lower than the PRG value to protect the WRW at the same risk level (i.e., 1×10^{-6}).

Table C-14. PRGs for POU Rural Resident Exposure Scenario[a] (pCi/g)

Isotope	2002[b] (pCi/g)			2017 (using ICRP 107) (pCi/g)		
Risk Level	**1×10^{-4}**	**1×10^{-5}**	**1×10^{-6}**	**1×10^{-4}**	**1×10^{-5}**	**1×10^{-6}**
^{241}Am	70	7.0	1.0	53.5	5.35	0.535
^{239}Pu	128	13.0	1.0	43.5	4.35	0.435
^{240}Pu	Not available[c]			43.6	4.36	0.436
^{234}U	36	4	0.4	12.3	1.23	0.123
^{235}U	11	1	0.1	11.4	1.14	0.114
^{238}U	40	4	0.4	13.6	1.36	0.136

[a] The rural resident exposure scenario is more conservative than the WRW and WRV exposure scenarios applicable to the COU.
[b] DOE, EPA, CDPHE 2002
[c] The source document for the 2002 PRGs only included a PRG for ^{239}Pu; a PRG for ^{240}Pu was not included in the source document.

C4.0 OU3

A Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation (RFI/RI) report and baseline risk assessment (BRA) were completed for OU3 in June 1996 (DOE 1996). This report identified the COCs in OU3 as $^{239/240}$Pu ~~239/240~~ and ^{241}Am ~~241~~ in surface soils and $^{239/240}$Pu ~~239/240~~ in surface sediments within the Great Western Reservoir. Although COCs were only identified for surface soil and sediment in OU3, the Facility Investigation/Remedial Investigation gathered and considered a substantial amount of surface water, groundwater, and air data. The BRA included evaluation of residential and recreational exposure scenarios and concluded that conditions in OU3 were within the acceptable risk range for protection of human health. The CAD/ROD for OU3 was published in June 1997 and selected no action as the remedy (DOE, EPA, and CDPHE 1997).

C4.1 Radiological Constituents Review Methodology and Results

The 2017 PRGs calculated for the POU rural resident in Table C-14 were compared to the PRGs originally calculated for OU3 in 1994. The 2017 PRGs used for the FYR risk review of the POU were used for the OU3 comparison because these PRGs were calculated using the most up to date input parameters for a residential scenario. As with the COU and POU risk reviews, no new data were collected for the FYR risk review for OU3. ~~evaluations, the 2017 EPA online calculator was used as a basis to generate site-specific PRGs for OU3 that could then be compared to the PRGs from 1994, assuming the same calculator data inputs. No new data were collected for this FYR risk evaluation for OU3. As with the other OUs, in order to perform PRG calculations using the site-specific data from 1994, calculations were performed using Microsoft Excel (instead of the EPA PRG online calculator). The EPA PRG equations used in the online~~

calculator were written into an Excel spreadsheet calculator and then validated for accuracy. For OU3, the residential scenario was used in the Excel calculator, using values provided in the 1994 *Programmatic Risk Based Preliminary Remediation Goals* document (DOE 1994).

Figures C-5 and C-6 present the equations used to calculate the PRG for exposure to soil using a residential scenario. As evidenced in these figures and in the resulting comparison of calculated PRGs described later in this section, there have been several changes to input parameters and equations used in the risk assessment since 1994. This presented a challenge when entering the 1994 input parameters into the present-day PRG calculator because some input parameters were not considered in 1994 that are now required input into the EPA PRG calculator.

$$PPRG_1 = \frac{TR \times AT \times 365\ days/year}{EF \times \left[(SFi \times IRa \times ED \times \frac{1}{BW} \times \frac{1}{PEF}) + (SFo \times 10^{-6}\ kg/mg \times IF) \right]}$$

where:

Variable	Explanation (Units)	Default Value
~~$PPRG_1$~~	~~Risk-based PPRG for surface soil based on residential use (mg/kg)~~	~~-~~
TR	target excess lifetime cancer risk (unitless)	10^{-6}
AT	averaging time (years)	70 years
EF	exposure frequency (days/year)	350 days/year
SFi	inhalation cancer slope factor $(mg/kg\text{-}day)^{-1}$	COC-Specific
IRa	daily inhalation rate (m^3/day)	20 m^3/day
ED	exposure duration (years)	30 years
BW	adult body weight (kg)	70 kg
PEF	particulate emission factor (m^3/kg)	4.63×10^9 m^3/kg
SFo	oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	COC-Specific
IF	age-adjusted soil ingestion factor (mg-yr/kg-day)	114 mg-yr/kg-day

~~Figure C-5. 1994 Equation for Resident Soil PRG~~

Resident Soil (Default Input Values Shown)

- incidental ingestion of soil

$$PRG_{res\text{-}soil\text{-}ing}(pCi/g) = \frac{TR \times t_{res}(year) \times \Lambda\left(\frac{1}{year}\right)}{\left(1-e^{-\lambda t_{res}}\right) \times SF_s\left(\frac{risk}{pCi}\right) \times IFS_{res\text{-}adj}(1{,}120{,}000\ mg) \times \left(\frac{g}{1000\ mg}\right)}$$

where:

$$IFS_{res\text{-}adj}(1{,}120{,}000\ mg) = \left(\left(EF_{res\text{-}c}\left(\frac{350\ days}{year}\right) \times ED_{res\text{-}c}(5\ years) \times IRS_{res\text{-}c}\left(\frac{200\ mg}{day}\right)\right) + \left(EF_{res\text{-}a}\left(\frac{350\ days}{year}\right) \times ED_{res\text{-}a}(20\ years) \times IRS_{res\text{-}a}\left(\frac{100\ mg}{day}\right)\right)\right)$$

- inhalation of particulates emitted from soil

$$PRG_{res\text{-}soil\text{-}inh}(pCi/g) = \frac{TR \times t_{res}(year) \times \Lambda\left(\frac{1}{year}\right)}{\left(1-e^{-\lambda t_{res}}\right) \times SF_i\left(\frac{risk}{pCi}\right) \times IFA_{res\text{-}adj}(161{,}000\ m^3) \times \frac{1}{PEF\left(\frac{m^3}{kg}\right)} \times \left(\frac{1000\ g}{kg}\right)}$$

where:

$$IFA_{res\text{-}adj}(161{,}000\ m^3) = \left(\left(EF_{res\text{-}c}\left(\frac{350\ days}{year}\right) \times ED_{res\text{-}c}(6\ years) \times ET_{res\text{-}c}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times IRA_{res\text{-}c}\left(\frac{10\ m^3}{day}\right)\right) + \left(EF_{res\text{-}a}\left(\frac{350\ days}{year}\right) \times ED_{res\text{-}a}(20\ years) \times ET_{res\text{-}a}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times IRA_{res\text{-}a}\left(\frac{20\ m^3}{day}\right)\right)\right)$$

- external exposure to ionizing radiation

$$PRG_{res\text{-}soil\text{-}ext}(pCi/g) = \frac{TR \times t_{res}(year) \times \Lambda\left(\frac{1}{year}\right)}{\left(1-e^{-\lambda t_{res}}\right) \times SF_{ext\text{-}sv}\left(\frac{risk/year}{pCi/g}\right) \times EF_{res}\left(\frac{350\ days}{year}\right) \times \left(\frac{1\ year}{365\ days}\right) \times ED_{res}(26\ years) \times ACF_{ext\text{-}sv} \times \left[\left(ET_{res\text{-}o}\left(\frac{1.752\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times GSF_{o\text{-}ext\text{-}sv}(1.0)\right) + \left(ET_{res\text{-}i}\left(\frac{16.416\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times GSF_i(0.4) \times GSF_b(1.0)\right)\right]}$$

Figure C-6. 2017 Equation for Resident Soil PRG

- consumption of fruits and vegetables back-calculated to soil

$$PRG_{res\text{-}soil\text{-}produce\text{-}ing\text{-}tot}(pCi/g) = \frac{1}{\left(\sum_{i=1}^{n} \frac{1}{PRG_{res\text{-}soil\text{-}produce\text{-}ing}(pCi/g)_i}\right)}$$

where:

n = total number of produce items included

and:

$$PRG_{res\text{-}soil\text{-}produce\text{-}ing}(pCi/g) = \frac{PRG_{res\text{-}produce\text{-}ing}(pCi/g)}{\left(R_{upv} + R_{es}\right)} \times \left(\frac{t_{res}(year) \times \lambda\left(\frac{1}{year}\right)}{\left(1 - e^{-\lambda t_{res}}\right)}\right)$$

where:

$$R_{upv} = Bv_{wet} \; ; \; R_{es} = MLF_{produce}$$

- consumption of fruits and vegetables.

$$PRG_{res\text{-}produce\text{-}ing}(pCi/g) = \frac{TR}{SF_f\left(\frac{risk}{pCi}\right) \times IF_{res\text{-}adj}(g) \times CF_{res\text{-}produce}(1)}$$

where:

$$IF_{res\text{-}adj}(g) = \left(\left(EF_{res\text{-}c}\left(\frac{350\ days}{year}\right) \times ED_{res\text{-}c}(6\ years) \times IR_{res\text{-}c}\left(\frac{g}{day}\right)\right) + \left(EF_{res\text{-}a}\left(\frac{350\ days}{year}\right) \times ED_{res\text{-}a}(20\ years) \times IR_{res\text{-}a}\left(\frac{g}{day}\right)\right)\right)$$

- total

$$PRG_{res\text{-}soil\text{-}tot}(pCi/g) = \frac{1}{\frac{1}{PRG_{res\text{-}soil\text{-}ing}} + \frac{1}{PRG_{res\text{-}soil\text{-}inh}} + \frac{1}{PRG_{res\text{-}soil\text{-}ext}} + \frac{1}{PRG_{res\text{-}soil\text{-}produce\text{-}ing\text{-}tot}}}$$

Figure C-6. 2017 Equation for Resident Soil PRG (continued)

For example, the 2017 online PRG calculator requires input for each individual element that makes up the overall particulate emission factor (PEF) in order to calculate site-specific PRG values. The calculator does not allow input of a single PEF value, which was the only PEF input parameter available in the 1994 calculations. Figure C-7 shows the PEF screen from the 2017 PRG calculator. Because some of the input data required to use the 2017 online PRG calculator were not in the 1994 dataset, the Excel calculator described in Section C2.3.3 was used. Although default values are available in the 2017 calculator, using default values from 2017 coupled with site-specific values from 1994 would result in a completely different scenario. For the purposes of this FYR risk evaluation, such a comparison would not be meaningful.

Default ▾ City (Climatic Zone) – Selection based on most likely climatic conditions for the site	11.32 U_t (equivalent threshold value)
	0.5 V (fraction of vegetative cover) unitless
.5 A_s (acres)	
4.69 U_m (mean annual wind speed) m/s	

Figure C-7. 2017 Input Required for Particulate Emission Factor (PEF)

C4.1.1 Radionuclide Constituent Evaluation Results

To be able to compare current and previous PRGs from OU3, the 2017 EPA online calculator was used as a basis to generate site-specific PRGs that could then be compared to the PRGs from 1994, assuming the same calculator data inputs for the residential exposure scenario. It should be noted that the 2017 calculations for the resident scenario do not take into account any vegetable consumption from the soil as these data were not included in the 1994 dataset.

Table C-15 presents the OU3 PRGs calculated in from 1994 and the Excel calculator 2017 PRGs from Table C-14. at a risk level of 1×10^{-6} (1 in 1,000,000). As shown in the table, the PRGs are within the acceptable 1×10^{-6} risk range, except for U-234 and U-238. The PRG results for U-234 (45.3 pCi/g in 1994; 5.09 pCi/g in 2017) and U-238 (46.0 pCi/g in 1994; 5.63 pCi/g in 2017) changed significantly. As shown in Table C-15, the calculated 2017 PRGs at the 1 x 10^{-6} risk level for ^{241}Am, ^{239}Pu, ^{240}Pu, ^{234}U, and ^{238}U are much smaller than those calculated in 1994 at the same risk level. This is due to the numerous changes to input parameters (e.g., slope factors) and risk assessment equations that have been adopted by EPA since 1994. An analysis of the changes to the PRGs for these two U isotopes indicate the overall risk from U-234 and U-238 have increased slightly due to slope factor changes. The comparison of slope factor changes from 1994 to 2017 is shown in Table C-8. Comparing the 1994 PRG concentrations for the resident scenario to the Excel calculator values demonstrates that the 1994 U-234 and U-238 PRGs would present a risk slightly below 1×10^{-5} (Table C-16), which is still within the EPA acceptable risk range. The most significant differences between the 1994 and 2017 PRGs are for ^{234}U and ^{238}U. As stated in the 1996 RFI/RI for OU3, U isotopes were not considered to be above background concentrations and were not identified as COCs. However, Tto provide perspective, the maximum concentration of ^{234}U-234 and ^{238}U-238 identified at OU3 in 1994 was in subsurface soil (DOE 1996). Uranium-234 was detected at 2.02 pCi/g, and ^{238}Uuranium-238 was detected at 2.15 pCi/g, which are both below the 2017 resident PRGs calculated for this review. within the EPA acceptable risk range, as shown in Table C-15. As stated in the 1996 CAD/ROD, the only COCs identified for OU3 were ^{239}Pu, ^{240}Pu, and ^{241}Am (DOE, EPA, CDPHE 1997). The highest surface soil level for $^{239/240}$Pu was 6.47 pCi/g and for ^{241}Am was 0.52 pCi/g (DOE, EPA, CDPHE 1997). A comparison of these data with the 2017 PRGs calculated for the rural resident demonstrates that the highest Pu and Am levels measured at OU3 fall within the EPA acceptable risk range considered by EPA to be protective of human health (Table C-15). As such, Based on this risk review, OU3 continues to meet the conditions for UU/UE.

Table C-15. PRGs for OU3 Residential Exposure Scenario

Isotope	1994[a] (pCi/g)	2017 (pCi/g)		
Risk Level	1×10^{-6}	1×10^{-4}	1×10^{-5}	1×10^{-6}
^{241}Am	2.37	53.5	5.35	0.535
^{239}Pu	3.43	43.5	4.35	0.435
^{240}Pu	3.42	43.6	4.36	0.436
^{234}U	45.3	12.3	1.23	0.123
^{235}U	0.17	11.4	1.14	0.114
^{238}U	46.0	13.6	1.36	0.136

[a] DOE 1994

~~*Table C-16. Recalculated PRGs for U-234 and U-238 (pCi/g at a 9 × 10^{-6} risk level)*~~

~~Isotope~~	~~1994~~	~~2017 (using ICRP 107)~~
~~^{234}U~~	~~45.3~~	~~45.8~~
~~^{238}U~~	~~46.0~~	~~50.7~~

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